2019-03-29

STUDY ON IMPROVING ASSEMBLEY LINE BALANCING IN APPAREL INDUSTRY: A CASE STUDY ON TELAJE GARMENT MANUFACTURING AND SALES PRIVATE LIMITED COMPANY

Bahir Dar University **Ethiopian Institute of Textile and Fashion Technology**

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BAHIR DAR UNIVERSITY

YEAR 2018

STUDY ON IMPROVING ASSEMBLEY LINE BALANCING IN APPAREL INDUSTRY: A CASE STUDY ON TELAJE GARMENT MANUFACTURING AND SALES PRIVATE LIMITED COMPANY

By

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A Thesis Submitted to the

Ethiopian Institute of Textile and Fashion Technology
In partial fulfilment of the requirements for the Degree of master of education
in

Garment Technology

Under the Supervision of

Abera Kechi (PHD.)

Ethiopian Institute of Textile and Fashion Technology

Bahir Dar University

Bahir Dar

September 2018

ABSTRACT

Apparel industry is one of the oldest and among the most global industry being primary concerned with the design and production of cloth and their supply. The central process in the apparel manufacturing is the joining together of Garment components which is known as the sewing process , which is the most labour intensive type of manufacturing process.Proper Utilization of resource in garment sewing section is more critical to enhance performance of the apparel industry with reducing production cost and minimizing wastage. For effective utilization of resource in sewing section good line balancing is important in order to increase productivity and production efficiency

This research was design to analyse and improving assembling line in case of Telaje garment manufacturing and sales private limited company.Study was first conduct observations in production floor and start work with the selection of sewing line in garment production process. Among nine lines of the factory select one on the production floor and one garment ordered product known us five pockets men's jeans trouser. For this study both qualitative and quantitative research approaches were employed. Both primary and secondary data source are used to detailed collected relevant data to accomplish this thesis works.

The main problems facing with Telaje garment manufacturing and sales Plc are: irregular material flows, long production lead time, bottlenecking, and low productivity. To eliminate the problems implementation of proper line balancing is mandatory,However,Telaje garment manufacturing and sales Plc do not implement proper line balance in production system due to lack of skill and nature of difficulty of line balancing when they want to change or modify the assembly line, therefore this thesis work shows that bottleneck process and consequence solution would be searched, and significantly improving productivity by 387 unit product/ day and, hence Line efficiency would increase from 29.1% to 50.04% of the line.

Key words; Assembly line, Line balancing, Bottleneck, Productivity

ADVISORS'APPROVAL SHEET

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This is to certify that the thesis title "STUDY ON IMPROVING ASSEMBLEY LINE BALANCING IN APPAREL INDUSTRY CAUSE STUDY ON TELAJE GARMENT MANUFACTURING AND SALES PRIVATE LIMITED COMPANY'' Submitted in partial fulfilment of the requirements for the degree of masters with specialization in Garment technology the graduate program of the Ethiopian institute of textile and fashion technology and has been carried out by YOHANNES ADMASSU ID. NO. MGT/S/030/07 under my/our supervision, therefore, I recommend that the student fulfilled the requirements and hence hereby can submit the thesis to the institute.

____________________________	______________________	_____
Name of major advisor	signature	Date
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Name of co- advisor	signature	Date

APPROVAL PAGE

I certify that I have supervised /read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in quality and scope, as a thesis for the fulfilment of the requirements for the degree of masters of education in garment technology.

________________	________________	________________
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External Examiner 2	Academic status	Signature
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Internal Examiner	Chairman Academic status (Examination Committee Member)	Signature

This thesis was submitted to the Ethiopian Institute of Textile and Fashion Technology Bahir Dar University and is accepted as a fulfilment of the requirement for the degree of masters of Education in Garment technology.

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Declaration

I hereby declare that the thesis is submitted in the fulfilment of the Master's degree is my own work and that all contributions from any other persons or sources are properly and dual cited. I further declare that the material has not been submitted either in whole or in part, for a degree at this or any other university in making this declaration, I understand and acknowledge any breaches in this declaration constitute academic misconducts, which may result in my expulsion from the program and/or exclusion from the award of degree.

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Date

ACKNOWLEDGEMENT

My special heartfelt tanks goes to Abera kechi (PHD), my advisers for his unreserved, critical and constructive professional comment for accomplish this thesis. And also my heartfelt acknowledge goes to Telaje garment manufacturing and sales private limited company human resource department, line supervisor and operator for here encourage, comment and suggestion.

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LIST OF ABBREVIATIONS

ALB= assembly line balancing problem.

MALBP=Multi-manned assembly line balancing problems

PLC=private limited

MMAL=Mixed-Model Assembly Line

HR=human resource

IE=industrial engineering

SAM= Standard allowed minute

QC=quality control

EITEX = Ethiopia institute of textile and fashion technology

BDU=Bahir Dar university

APH = Automatic pocket hemming machine

ADPc = Automatic pockets creasing machine

APc =Auto pocket stitching machine

SNLS = Single needle lock stitch

FOA =Feed of the arm

3TO/L =3 thread over lock (over edge)

5TF/L = 5 thread flat lock (cover stitch)

4TO/L =4 thread over lock

5TO/L = 5 thread over lock

DNLS =Double needle lock stitch

3TF/L =3 thread flat lock (cover stitch)

APJ =Auto J-stitch making

DNFPH = Double needle front pocket hemming

WBAM =Waistband attach machine

ABLA =Auto loop attach

BHM = Bottom hemming machine

CHAPTER ONE

INTRODUCTION

1.1 Background

As a supply chain of textile industry, garment industry is one of the major industries of the world. The production process of garments is separated into four main phases: designing/ clothing pattern generation,fabric spreading and cutting, sewing and ironing and packing.The joining together of garment components, known as the sewing process which is the most labour intensive part of garment manufacturing. Furthermore, since sewing process is labour intensive; apart from material costs, the cost structure of the sewing process is also important. Therefore, this process is of critical importance and needs to be planned more carefully As a consequence, good line balancing with small stocks in the sewing line has to be drawn up to increase the efficiency and quality of production. The production process includes a set of workstations, at each of which a specific task is carried out in a restricted sequence, with hundreds of employees and thousands of bundles of sub-assemblies producing different styles simultaneously. An assembly line is defined as a set of distinct tasks which is assigned to a set of workstations linked together by a transport mechanism under detailed assembling sequences specifying how the assembling process flows from one station to another .In assembly line balancing, allocation of jobs to machines is based on the objective of minimizing the workflow among the operators, reducing the throughput time as well as the work in progress and thus increasing the productivity. Sharing a job of work between several people is called division of labour. Division of labour should be balanced equally by ensuring the time spent at each station approximately the same. Each individual step in the assembly of product has to be analysed carefully, and allocated to stations in a balanced way over the available workstations. Each operator then carries out operations properly and the work flow is synchronized. Manufacturing a product in an assembly line requires partitioning the total amount of work into a set of elementary operations called tasks. Tasks are assigned to operators depending on constrains of different labour skill levels. Assembly lines have been widely used in various production systems to produce high volume standardized products. An assembly line includes a series of stations arranged along a material handling system. The components are processed depending on a set of tasks for a given cycle time. Tasks are assigned to an ordered sequence of stations according to a given precedence relationship among them. The problem of assigning tasks to stations to optimize a specific objective, such as minimizing the number of stations for a given cycle time, minimizing the cycle time for a given number of stations, or maximizing the efficiency of assembly line, subject to the precedence relationships among tasks, is called the assembly line balancing (ALB) problem. Multi-manned assembly line balancing problems (MALBP) are a new type of generalized assembly line balancing problems in which there is the possibility of assigning more than one operator to each work station according to the product features. These types of balancing problems typically occur in industries with high volume of products. In this type of assembly line, in each workstation instead of one worker several workers simultaneously perform different operations on the same individual product. The main goal of using this kind of multi-manned workstations is to minimize the number of workstations of the line while the total effectiveness of the line (in terms of number of workers) remains optimal. In this work the asses' assembly line balancing of sewing section to enhance productivity and efficiency of the company

1.2 Back ground of Telaje garment manufacturing and sales plc.

Telaje Garment Manufacturing and Sales private limited company (Plc.) is one of the new established companies which are found under manufacturing cluster of Tiret corporate. This garment factory has been set up with the vision to sustainable produce high quality denim jeans trousers and denim jeans shirts to meet the exact standards of the leading international brands. These objectives are being achieved through invest in the latest technology and highly qualified workers. The garment factory located in south wollo zone kombolcha town, specifically in kombolcha textile Share Company's empty factory space 3000m2 which are rented.Kombolcha is the most preferred industrial area as it is the nearest of all possible industrial areas of Amhara regional state to port Djibouti (about 533km) and there is a developed industrial culture already built as there are many previously installed manufacturing plants both textile and garment related and others. Besides, access to raw materials, skilled technicians, and basic infrastructure is easier and it's also nearer to the capital city (only 375km away) of Ethiopia Adiss Ababa.

https://www.facebook.com/.../Telaje-Garment-Manufacturing-Sales-PLC-575555622655...

Figure 1.1: line layout and some product of the factory (photo captured)

1.3 Justification

Line balancing aims at grouping the resources or labour in an efficient and best pattern in order to obtain an optimum or proper balance of the resources and flows of the production or assembly processes. The assembly line needs to be designed effectively and tasks needs to be distributed among workers, machines and work stations ensuring that every line segments in the production process can be met within the time frame and available production capacity. Assembly line balancing can also be defined as assigning proper number of workers or machines for each operations of an assembly line so as to meet required production rate with minimum or zero ideal time. With this thesis work to asses' Telaje garment line balancing for proper use of resources to improve efficiency and productivity in sewing section.

1.4 Statement of the Problem

This thesis work is designed to analyse and improving assembly line balancing of Telaje garment manufacturing and sales plc. During the survey of author the current assembly line balancing has face many problems and some of them are maximum idle time of operator and machine, an equal work content of individual operators, Input delay , Irregular material flow and Inconsistent quality. Those affect the rate of production, target production outputs, production quality, production efficiency and collectively Profit of a factory.

For this reason this research work is initiated and designed for analysing the assemble line balance based on work study and time study, finally recommend solutions will be found to identify bottleneck operation and make it to balance in overall production line of sewing section. Finally improve significantly in productivity and efficiency as compared to the existing scenario.

1.5 Significance of the study

These studies help to identify the bottleneck operation and draw back of the existing scenario.it focus on proper utilization of resource by minimizing limitation of the existing scenario in order to improve productivity and efficiency of garment sewing section by applying of proper line balancing.

1.6 Purpose of research study

The purpose of this study is to improve sewing line efficiency by applying of proper line balance technique.

1.7 Objectives of the thesis

1.7.1 General objective:

To improve assembly line balancing of Telaje garment factory.

1.7.2 Specific objectives:

- To analyse the existing method
- To identify the bottleneck area in production line
- Find solutions for bottleneck area
- To make modified balanced line

1.8 Scope of the study

The scopes of this study were one production line and ordered products known as five pockets jeans men trouser in garment sewing section of Telaje garment.

1.9 Benefit and benefiters

1.9.1 Benefit of study

The benefits of this thesis work are enhancing profit of the company by improving productivity and efficiency of the company by applying of proper assembly line balance.

1.9.2 Beneficiary

- Operators(worker) when the factory improve productivity and efficiency the total profit of the factory also increase so that an individual operator also gain this profit directly or indirectly and also improving working condition of the factory operator work at condensive atmosphere and increasing moral and job satisfaction.
- Customer when the factory produce right product at right quality, in right place, at right time customer directly benefit in order to get good quality product within time frame based on their expectation.

- Company improve productivity and efficiency and also finally increase total profit.
- University this research work improve linkage between university, industry and society
- Researchers improve their knowledge , attitude and skill the field study and finally get certify as reward
- country when this research work implement on the ground the factory performance improve and an operator within the factory life improve then collectively country economy, social and political improve

CHAPTER TWO

LITERATURES REVIEW

The apparel industry is one of the oldest, largest and among the most global industries being primarily concerned with the, design and production of clothing and their supply. It is the typical ‘starter’ industry for countries engaged in export orientated industrialization and is labour intensive (Md. M. Islam 2015). Apparel structure has changed from the custom fitting and assembly of individual hand-sewn garments to the mechanized, automated and sometimes robotized mass production and distribution of ready-to-wear products in the world market (Tyler, 1991). Line balancing in apparel industry 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 (Md. M. Islam 2015). When you consider mass production, garments are produced in lines or set of machines instead of single machine. The line arrangement of sewing machine depends on what types of garments manufacture in sewing floor in apparel manufacturing industry; most garment manufacturers use the assembly line for making clothes and garments (Md. M. Islam 2015). In the assembly line, a number of sewing machines (including different types of sewing machines and non-sewing equipment) are placed in a line according to the process sequence requirement. This process is of critical importance and needs to be planned more carefully (Tyler, 1991). As a consequence, good line balancing with small stocks in the sewing line has to be drawn up to increase the Efficiency and quality of production (Tyler, 1991).An assembly line is defined as a set of distinct tasks which is assigned to a set of Workstations linked together by a transport mechanism under detailed assembling sequences specifying how the assembling process flows from one station to another (Tyler, 1991). In assembly line balancing, allocation of jobs to machines is based on the objective of minimizing the workflow among the operators, reducing the throughput time as well as the work in progress and thus increasing the productivity. Sharing a job of work between several people is called division of labour. Division of labour should be balanced equally by ensuring the time spent at each station approximately the same. Each individual step in the assembly of product has to be analysed carefully, and allocated to stations in a balanced way over the available workstations. Each operator then carries out operations properly and the work flow is synchronized. In a detailed work flow, synchronized line includes short distances between stations, low volume of work in process, precise of planning of production times, and predictable production quantity (Eberle et al, 2004).

According to (Aadarsh Adeppa,2015) ,There are many different types of assembly line systems some common variations include the classic automated intermittent and lean manufacturing models. These assembly line systems are often used for making different types of products. Assembly lines have some shared characteristics (Aadarsh Adeppa, 2015).

1. Single model assembly line. Single model assembly line is a type of assembly line in which assemblers work on the same product.
2. Mixed Model assembly line. In mixed-model production is the practice of assembling several distinct models of a product on the same assembly line without changeovers and then sequencing those models in a way that smoothest the demand for upstream components. Setup times between models could be reduced sufficiently enough to be ignored, so that intermixed model sequences can be assembled on the same line. In spite of the tremendous efforts to make production systems more versatile, this usually requires very homogeneous production processes. The objective is to smooth demand on upstream work centres, manufacturing cells or suppliers and thereby reduce inventory, eliminate changeovers, improve operation. It also eliminates difficult assembly line changeovers. The Mixed-Model Assembly Line (MMAL) is a more complex to balance in which several types of the products are assembled simultaneously on the line which considering to the shape of line.
3. Multi Model Assembly lines. Multi-product production supports process manufacturers where multiple or single components are run through

a processing line which delivers multiple end items or finished products, including waste or by-products. Serial/Lot control for components and end items is available, as is a variety of costing and yield methods.

4. Peace and unplaced assembly lines. In paced assembly systems a fixed time value restricts the work content of stations (further assumes that the cycle time of all stations is equal to the same value). Assembly lines with this attribute are called paced, as all stations can begin with their operations at the same point in time and also pass on work pieces at the same rate. In unplaced lines, work pieces do not need to wait until a predetermined time span is elapsed, but are rather transferred when the required operations are finished.

A line may be assembly line, modular line or section, a line set with online finishing and packing (V Ramesh Babu, 2006). 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. Assembly Line Balancing (ALB) is the term commonly used to refer to the decision process of Assigning tasks to workstations in a serial production system (Prabhuling Umarani, Keshav Valase 2017).The task consists of elemental operations required to convert raw material in to finished good.

2.1 Line Balancing:

Line balancing means balancing the production line, or any assembly line. The main objective of line balancing is to distribute the task over the each work station so that idle time of labour of machine can be minimized (Naveen Kumar & Dalgobind Mahto2013). Line balancing aims at grouping the resources or labour in an efficient and best pattern in order to obtain an optimum or proper balance of the resources and flows of the production or assembly processes. Assembly Line Balancing (ALB) is the term commonly used to refer to the decision process of assigning tasks to workstations in a sequence way to production system. The task of elemental operations required to build raw material in to finished product. Most products are made up of various parts, where a part can be described as a single unit of a product that are brought together with others to form the finished product. Assembly, therefore, can be explained as the operation of bringing parts together, either manually by operators or automatically by robots, to form a finished product. Garment manufacturing is a traditional industry with global competition.

Line balancing is known as the systematic arrangement of machines and allocation of operation and helper in a sewing line in such a way that smooth production can be possible with minimizing the idle time. In the garments industry, Line balancing is known allocation of sewing machines, according to the garments pattern and design. The line arrangement of sewing machine depends on what types of garments manufacture in sewing floor. Proper line balancing in an apparel industry may increase productivity (Tyler, 1991).

There are two types of line balancing that include Static Balance and Dynamic Balance (Rajkumar P. Patil, 2012). Static Balance denotes long-term differences in capacity over a period of several hours or longer. Static imbalance results in underutilization of workstations, machines and people. Dynamic Balance refers to short-term differences in capacity such as over a period of minutes, hours at most. Dynamic imbalance occurs from product mix changes and difference in work time dissimilar to product mix. Production-line balancing study tends to employ thought and ingenuity to change conditions. Production-line design and operation is more art than science. Labour flexibility is the key to effective resource management. The idea of worker's checking and doing minor repair work on their own equipment possibly decreases the risk of equipment failure. Selecting an appropriate set of balancing mechanism is a part of work cell design and it must be linked with many other decisions for the system to function well. The prerequisite of this method is to have a skill matrix of sewing operators. Line becomes imbalanced and lot of productive time is lost as operators sit idle. To utilize operator's maximum capacity, work allocation must be done based on operator’s potential performance level (efficiency) and work must be shared with operators who has excess capacity.

2.2 How to Balance a Traditional Sewing Line

According to Mustafizur Rahman Shanto (2017), Line balancing means allocation of sewing machine according to design. A sequence of operations is involved in making a garment. In bulk garment production, generally a team workin an assembly line (Progressive Bundle system) and each operator do one operation and give it other operator to do next operation. In this way garment reached to end of the line as a completed garment. In the assembly line after some time of the line setting, it is found that at some places in the line, work is started to pile up and few operators sit idle due to unavailability of work. When this situation happens in the line it is called an imbalanced line.

Normally it happens due to two main reasons –

1. Variation in work content (time needed to do an operation) in different operations.
2. Operator’s performance level. To meet the production target, maintaining smooth work flow in the line is very important. So it is very important to know basics of quick line balancing.

How to balance an imbalanced line has been explained in the following. The main job in line balancing is to eliminate or reduce WIP (work in process) at bottleneck operations. To do that you have to know which operations are bottleneck in the line. Through capacity study and target setting you will find existing bottlenecks in the line.

Step 1: Capacity study:

List down all operations (with operator name) as per operation sequence in a paper. Using stop watch cycle time (time study) for each operation for five consecutive cycles. With average cycle time calculate hourly capacity of the operators. (I.e. operation cycle time 30 seconds and total allowances is 20% then capacity is 100 pieces per hour). Draw a line graph with per hour capacity data.

Step 2: Target setting:

With the above capacity data set your target output per hour from one line. Generally it is calculated using following formula (Target per hour= Total no of operators X 60 /garment SAM). Check current hourly operator production report. Draw a straight line with target output data on the line graph.

Step 3: Identification of bottleneck areas:

Now go to the capacity study table and compare each operator's capacity with the target capacity. Each individual operator whose capacity is

Less than the target output is bottleneck operation for the line. It is impossible to improve imbalance line's output without improving output of the bottleneck operations. A bottleneck operation is like a weak link chain.

Step 4: Eliminate bottlenecks from the line:

Now to eliminate bottleneck areas use following methods which suites best to your situation but don't jump without trying initial steps-

1. Club operations where possible. Where there is higher capacity than the target output, give that operator another operation with less work content. Considering machine type and sewing thread colors.
2. Shuffle operators. Operations that have low work content use low performer there. And where work content is higher use high performers.
3. Reduce cycle time using work aids and attachments. To assist the operator in handling parts during sewing, positioning cutting and disposing finished task, work aids, guides or attachment can be used. Think of that if possible provide operator with aids. It will reduce operation cycle time.
4. Improve workstation layout and improve methods. Most important area for improving output from a particular operation is using best workstation layout and best method of work. There is always a chance that though improving method of bottleneck operations you can do line balancing.
5. Add more operators at bottleneck operations. Adding one additional machine in easy task than others. Before adding one more machine compare the cost-benefits of putting additional machine into the line. It can be simple compared by estimating machine productivity in both cases.

6. Do extra work at bottleneck operations. At lunch break and Tea break when each operator of the line goes for break, bottleneck operator can continue work to feed next to his operator. Later he can take break. At the end of the day tell this operator to work for one hour extra to reduce the WIP.

2.3 Widely Applied Balancing Procedure

The procedure to widely apply for line balancing method can be listed as follows. (Wickramasekara, A. N & Perera, H. S. C, 2016)

1. Collect the necessary information required; the list of operations in sequence, the standard time for each operation, the length of the working day and the planned output rate.
2. Compute the capacity per hour for each operation
3. Determine the required output rate
4. Workout the required Theoretical Manning Level for each operation to maintain the required output rate. An Improved Approach to Line Balancing for Garment Manufacturing
5. When you have fraction of operators, combine those operations with similar equipment to get operators with full numbers.
6. Assign operators to perform each operation considering the above calculation and the skill level of operators.

2.4 What Is Line Balancing With Engineered Garments?

Focusing area of line balancing with garment engineering (Mashiur Rahman, 2015) are listed below

- ✓ Every engineered garments process officers need to involve for the improvements their own line.
- ✓ Need to keep records of old and new method etc.
- ✓ Engineered garments need involved of the cost Saving activities to get the best productivity for the company
- ✓ Every Line of engineered garments need to do 3 improvements per week for the Goal

- ✓ Operator skill monitoring and update need to done daily basic
- ✓ Fabric & Operation analysis.
- ✓ Mock up making in critical operation with using correct folder/gauge and attachments
- ✓ Method studies
- ✓ Machine, gauge, folder & Manpower requirement and availability
- ✓ Understand the Operation Bulletin and Machine Layout
- ✓ Review the Production plan
- ✓ Training start if required in critical operations

2.5 How to Maintain Line Balancing in Garments:

In garments industry, organized arrangement of machinery and allocation of operation is a very important task for a production manager (Noor Ahmed Raaz, 2015).Therefore, this issue is also important for the merchandising department in a garment industry. On sewing floor, line balancing should be maintained according to the sewing machines sequence. Proper line balancing in a sewing floor can be found with the help of work study and SMV calculation. This line balancing process can be change according to the garment style and design, in talaje garment manufacturing and seals Plc. machine and resource was allocate based on operational sequence of five pocket jeans trouser .line balancing will be maintain according to this style .

2.6 Common line balancing problems

With so many different and potentially conflicting requirements on the system, as well as interdependencies between process constraints and design objectives, the outcomes of line balancing process design, or re-design, can be difficult to predict (Noor Ahmed Raaz, 2015). If new processes create bottlenecks at any point in the system, this can negatively impact the whole line and overall throughput. Designing a new system or re-designing an existing assembly line incorrectly can result in lost production, substantial revenue losses and overworked operators. Analytic methods can be used, but are limited due to the dynamic nature of the system. The impact of buffering, shift patterns, and product sequence quickly confounds this approach for line design and balancing.

Other factors that add complexity to the design of an assembly line include (Noor Ahmed Raaz, 2015):

- Availability of operators
- Size of line buffers
- Sequence and mix of product
- Delivery rates and volume
- Line Balancing Leadership
- Reliability of equipment

Workmen should lead the production line balancing effort, so that they can react quickly when line imbalances (static and dynamic) crop up as a result of changeover to make a different item or changes in the output rate (Rajkumar P. Patil, 2012).

Production-line balancing study tends to employ thought and ingenuity to change conditions. Production-line design and operation is more art than science. Labour flexibility is the key to effective resource management. The idea of worker's checking and doing minor repair work on their own equipment possibly decreases the risk of equipment failure. Selecting an appropriate set of balancing mechanism is a part of work cell design and it must be linked with many other decisions for the system to function well. The prerequisite of this method is to have a skill matrix of sewing operators (Md. M. Islam 2015). Normally, at the time of line setting, operators are selected based on their experience on operations. The calculated skill level of the operators on the operations is not considered at all. As a result after couple of hours, high skilled operators start sitting idle and low skilled operators stuck with their work. Thus line becomes imbalanced and lot of productive time is lost as operators sit idle. To utilize operator's maximum capacity, work allocation must be done based on operator's potential performance level (efficiency) and work must be shared with operators who has excess capacity.

2.7 Labour Balancing and Assignments

Strategy of production line stability is the tendency for labour assignments to be fixed. Labour feasibility is an important feature in the strategy of production line flexibility linked to individual skills and capabilities. When one worker is having problem in performing his assigned task and experiencing delay due to technical problem, other worker should move into help (Rajkumar P. Patil, 2013).

The management practice of deliberately pulling workers of the line when the line is running smoothly. The movement of whole crews from one dedicated line to another as the model mix changes. But when come to telaje garment manufacturing and seals Plc. labour assigned was a fixed manner somehow operator skill and capabilities was similar.

2.8 Line Balancing Preparation

According (Md. M. Islam 2015) in order to prepare a balance the following procedure are follows.

- ✓ Study the Operation Bulleting along with the sample
- ✓ Selecting the correct workers for each process by analysing their past records.
- ✓ Call up a meeting for Supervisors and Operators to make them understand of the new style and also new Targets, incentive, build up and Delivery date.
- ✓ Skill requirement to be given to Human resource department for arranging additional Manpower.
- ✓ Anticipate and emphasize on providing training on operations which can be a bottlenecks.
- ✓ Identification of the Line as per the Production Plan.
- ✓ Instructions and Guidance
- ✓ Stitching of Sample by, Line supervisor and supervisor Line Supervisor, and Line Quality Supervisor will follow up the quality points.
- ✓ Target rates been considered and verified while the sample is been made.
- ✓ A meeting called by the Unit Head to review the Sample.

- ✓ All the points are discussed, clarified and understood.
- ✓ Any construction, method or attachment issue will be cleared

2.9 Improve line balancing:

Purpose of balancing a line is to reduce operator's idle time or maximize operator utilization. In a balanced line work will flow smoothly and no time will be lost in waiting for work. At time of line setting select operators for the operation matching operator skill history and skill required. Following this method you will select highly skilled operators for higher work content operations. Once line is set conduct capacity study at a regular interval. Use pitch diagram method to find bottlenecks inside the line. Once you start increasing operator utilization through line balancing you will get extra pieces from the same resources in defined time.

2.10 Use work aids,attachments,guides,correct pressure foots and folders:

These are some kinds of time saving devises that facilitate operator to perform their work effectively with less effort. If work aids are used effectively operation cycle time can be reduced many fold than existing cycle time. In new and small factories where there is no experienced technical person (maintenance, IE personnel or production manager) generally not aware about the usage and availability of work aids (Karuna Singh 2016).

Continuous feeding to the sewing line: It is not a fault of production department if they did not get cuttings to sew. All plans and efforts towards productivity will fail if line is not been fed continuously. "No feeding or irregular feeding" is one of the top reasons for lower productivity in poorly managed factory. Poor production plan, wrong selection product mix in seasons and ineffective cutting department are the reasons that stop continuous feeding. Once operators get the rhythm, they should be given non-stop feeding until style changeover to keep up the productivity. If you know there is unavailability of cutting in near future then plan accordingly and don't call all operators for that duration (Karuna Singh 2016).

Training for Line supervisors: Line supervisors are shop floor managers. So each supervisor must be trained with fundamental management skills and communication skill. Still in most of the supervisors in Indian factories are raised from tailors. They don’t acquire technical qualification in supervising. But their main job is providing instruction, transferring information. For which communication skill training is required for supervisors.

Secondly, supervisor should understand the fundamental of industrial engineering like operation bulletin, skill matrix, workstation layout, movement, capacity study and theoretical line balancing etc. If they understood these, they can help engineers or work study boys to improve line performance. The above training will bring changes in managing and controlling the lines and will improve labour productivity.

Training to sewing operators: according to (Karuna Singh 2016) Operators are main resources in the apparel manufacturing. They are most valuable resource to the company. So, factory must work on developing operator skill where required. “Training is not cost but an investment” said by many experts. Production from an operator depends on his skill level to the task. A low skilled operator will consume higher resources (time) and give less output. You will find quality related issues with low skilled and untrained operators. As the skill level of the operators is increased through training lines output will improve. Training does mean lot of time and money. Training should be given only on specific tasks that will be performed by the operator.

Setting individual operator target: Instead of giving equal target to all operators working in a line, give individual target as per operator's skill level and capacity. Set an achievable target for each operator so that they would try to reach the target. This will help improving operator’s individual efficiency. Use tricks for increasing target step by step. Take care of the operators who are under target. They may need skill training.

Operator motivation: Operator’s will is the most crucial part in productivity improvement. If they are motivated, they will put enough efforts on the work. Employee motivation generally depends on various factors like work culture, HR policies, bonus on extra effort or achieving target. In garment manufacturing operator’s motivation come through extra money (Karuna Singh 2016). Operator motivation can be improve by sharing certain percentage of you profit made from operator's extra effort.

2.11 Terms in Line Balancing Technique

There is range of terms used in assembly line balancing system. Each of them has their meaning and purposes.

- ✓ Cycle Time: Maximum amount of time allowed at each station. This can be found by dividing required units to production time available per day (Aadarsh Adeppa 2015). This is the time expressed in minutes between two simultaneous products coming of the end of production line. The calculation of cycle time takes into consideration of the entire production quantities. If multiple lines are producing the same product, then the composite cycle time is less than the actual lapse time of any individual line.
- ✓ Lead Time: Summation of production times along the assembly line (Naveen Kumar & Dalgobind Mahto,2013)
- ✓ Bottleneck: Delay in transmission that slow down the production rate. This can be overcome by balancing the line (Naveen Kumar & Dalgobind Mahto, 2013).
- ✓ Task Precedence: It is the sequence by which tasks are carried out. It can be represented by nodes or graph. In assembly line the products have to obey this rule (Naveen Kumar & Dalgobind Mahto, 2013). The product cannot be moved to the next station if it doesn't complete at the previous station.
- ✓ SAM (Standard allowed minute): The amount of time required to complete a specific job or operation under existing condition, using the specified & standard method at a standard pace when there is plenty of repetitive work(Naveen Kumar & Dalgobind Mahto,2013) .

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

Factor that effect of standards minute value (SMV)

Now-a-days, Standard Minute Value (SMV) is used as a tool for the line balancing, production control and the estimation of efficiency. In a similar way, the time taken to do a job for making garments could depend upon a number of factors like (Noor Ahmed Raaz, 2015).

- The length of the Garment;
- The number of stitches per inch;
- The presentation of item;
- The pricing of garments.

- ✓ Allowance: Different types of allowances are allowed in apparel production floor. Such as personal time allowance, Delay allowances, Fatigue allowances etc.
- ✓ Idle time: A period when system is not in used but is available.
- ✓ Productivity is measured by achievement toward established goals based on relationships between inputs and output (Naveen Kumar & Dalgobind Mahto, 2013) .Generally in sewing section line balancing means allotment of operations or jobs based on the objective of minimizing the throughput time as well as the work in process and thus increasing productivity. In sewing room, the breakdown of the total work content of a garment into operations has traditionally included long, medium and short operations, the actual length being influenced by the amount of work content in the garment, predicted quantity of output of an individual style, and the number employed in the company manufacturing it, with the consequent potential for specialization among its operators and managers. An operation breakdown is a sequential list of all the operations involved in cutting, sewing and finishing a garment, component or style.
- ✓ Work station: A physical area where a worker with tools / one or more machines or unattended machines such as robot perform specific task in a production line (Gaither and Fraizer, 2001). The purpose of designing a good workstation layout is to minimize the material handling time as much as possible. Thus you can reduce operation cycle time. Secondary benefit of good workstation is operators can work at same pace without fatigue. When designing a workstation layout don't forget to consider ergonomics

- ✓ Hourly operator capacity: Employ work study personnel (if you don't have) and start checking operator capacity hourly. Compare actual operator's hourly production with their capacity (Rajkumar P. Patil, 2013). If production is less then question them why? It helps in two ways – first, when operator's capacity is checked at regular interval they will be under pressure. Secondly, work study personnel start thinking on methods how cycle time can be reduced. Using the capacity data, you can move ahead in balancing the line

2.12 Garment Rating and allowance

Rating: - rating is a subjective comparison of any condition or activity to a benchmark, based upon our experience. While the mechanics of time study record the time a task did take, applying a rating will determine the time a task should take. (Prasanta Sarkar, 2012)

What is 100% performance or Normal Performance?

The concept of 100% performance is a critical element of time study and performance measures. Normal performance is the rate of output which qualified workers will achieve without over-exertion over the working day shifts provided they know and adhere to the specified method and provided they are motivated to apply themselves to the work. This performance is denoted as 100% on standard rating and performance scales. A slower is performance rate, which will produce fewer pieces per hour, is recorded as a percentage below 100%. A faster performance rate that produces more pieces per hour is recorded as greater than 100%.

Characteristic of 100% Performance or Normal operator (Prasanta Sarkar, 2012)

- Fluid motions without hesitation
- No false starts or duplications
- Consistent, coordinated, effective rhythm
- No wasted actions or work
- Attention centred on the task

How to get accurate rating?

- To improve accuracy in rating an operator, observer must -
- Has knowledge of the operation and the specified method or standard operating procedures for that task.
- Concentrates on operator motions
- Is alert to fumbles, hesitations, and other lost motions- these are seldom or absent in 100% performance.
- Eliminates or ignores interruption or events, not in the operator's control.
- Avoids a corrupting bias when observing fast and slow operators in succession
- Knows that increasing the number of cycles observed increases accuracy

2.13 Standard Minutes (SAM) for Few Basic Garment Products

Can anybody estimate SAM (standard allowed minute) of a garment without seeing and/or analysing the garment? No. It is not possible (Prasanta Sarkar, 2012). To estimate SAM you have to analyse the garment carefully and check different factors that affect the SAM. SAM of a product varies according to the work content or simply according to number of operations, length of seams, fabric types, stitching accuracy needed, sewing technology to be used etc. But still many of us inquire for approximate SAM values for basic products, like Tee Shirt, Formal shirt, Formal trouser or jacket. An estimated SAM helps in capacity planning of the factory, calculating requirement of machineries and even helps to estimate CM (cut and make) costing of a garment. However, for better understanding I will suggest you first to read articles 'How to calculate SAM for a garment?' SAM is a short form of standard allowed minutes. It means a normal operator can complete a task within the allowed time (minute) when he works at 100% efficiency. Standard minutes (SAM) of few basic products have been listed down with its SAM range according to work content variation. In actual cases garment SAM may go outside of the limit depending the above factors. This list will be updated time to time adding more products.

Table 2.1: Standard minutes (SAM) of some product (Prasanta Sarkar, 2012)

	Product	SAM (Average)	SAM Range
1	Crew neck T-Shirt	8	6 to 12
2	Polo Shirt	15	10 to 20
3	Formal Full sleeve shirt	21	17 to 25
4	Formal trouser	35	
5	Sweat Shirt (Hooded)	45	35 to 55
6	Jacket(Suit)	101	70 to 135
7	Women blouse	18	15 to 45
8	Bra	18	16 to 30

2.14 Line lay out:

Line layout, it means designing the presentation of workstations in an assembly and showing the flow of work from start to end (Karuna Singh, 2016). It can be a simple line diagram. The rectangle boxes are indicating sewing workstation. The number marked inside the boxes are indicating operations sequence in the Operation Bulletin and arrows are showing the flow of work. The line layout is prepared after the operation bulletin is made.

When you prepare the line layout, you will see following cases and you will define a workflow on the line layout (Karuna Singh, 2016).

- You may need to assign more than one workstation for the same operation,
- You may need to use same machine (workstation) for more than one operations
- You may need to load bundles or garment component in multiple workstations

Why you prepare a line layout?

Benefit and application of line layout

- The line layout helps line supervisors to set the line for a new order in the least time.
- From the layout, you will get the exact requirement of machines and equipment. Production team can be better prepared
- Style changeover time can be reduced by preparing a detailed line layout and doing line set-up based on the line layout

Advantages of line layout may be less work in process than a skill centre configuration and less handling between operations. This means faster throughput time and less build-up of parts between operations with high quality.
Disadvantages of a line layout include potential bottlenecks (work build up) and work load imbalance. Each operation depends on the previous one, and downtime, absenteeism, and slow operators may interrupt the work Flow. To counteract these problems, some operators may need to cross-trained to perform more than one operation, and substitute machines must be readily available for immediate replacement if equipment breaks down. New trainees may be expected to meet production standards before being placed in a line position. Failure to meet production schedules for whatever reason may create a need to reroute work, shift personnel, or schedule to avoid further days (Karuna Singh, 2016).

2.15 Time Study:

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 (Pranjali Chandurkar, Madhuri Kakde and Abhishek Bhadane, 2015).Time study is most popular and used method for line balancing and solving bottlenecks.

2.16 Method Study

Method Study is the systematic recording and critical examination of existing and proposed ways of doing work, as a means of developing and applying easier and more effective methods and reducing cost (Pranjali Chandurkar, Madhuri Kakde, Abhishek Bhadane, 2015).
Objectives of Method Study:

- Improvement of process and procedure.
- Improvement in the design of plant and equipment.
- Improvement of layout.

- Improvement in the use of men, materials & machines.
- Economy in human effort and reduction of unnecessary fatigue.
- Improvement in safety standards.
- Development of better working environment.

2.17 Work Measurement

Work Measurement is an application of techniques designed to establish the time for a qualified worker to carry out a specified job at a defined level of performance (Pranjali Chandurkar, Madhuri Kakde, and Abhishek Bhadane2015)

- Techniques of Work Measurement
- Techniques of Work Measurement:
- Time study
- Work Sampling
- Synthesis from standard data.
- Analytical Estimating & Comparative Estimating.

2.18 Nine Ways to Increase Sewing Operator Efficiency

9 Ways to Increase Sewing Operator Efficiency (Prasanta Sarkar, 2012) are:-
The purpose of increasing operator efficiency is to reduce labour cost per unit. But how one can improve operator efficiency?

1. Develop operator's sewing skills through training on the job. Train them on good movements, correct material handling and better method of performing a job.
2. Motivate operators by providing incentive based on their performance (efficiency level).
3. Assign operators to the tasks on what they are skilled. If they are given operations on which operator is low skilled, they will work on less efficiency. If you don't have alternative skilled operator for a job, train your existing operator first to develop his/her skill level.
4. Improve work methods where possible by motion study and motion analysis. Eliminate excess motion from the existing working method.

5. Don't forget to design a good workstation layout based on operation requirement. Reduce excess reach. A good presentation of work is also important.
6. Supply work continuously to operators. While an operator is assigned a work with less work content and he/she had idle time, give him/her one more job.
7. Eliminate unnecessary of interruption by supervisors, quality checkers and others things like defective pieces is supplied to operators.
8. Give operators achievable target. Record operator hourly production and chase operators if they produce less than their capacity or given target.
9. Don't do much overtime. And you must have one day weekly off. By applying and adopting above means you can improve your operator's stitching efficiency from the existing efficiency level on the specific jobs. But to see the improvement you have to measure operator's existing efficiency and current efficiency

2.19 Summary

The production process of garments is separated into four main phases: designing/clothing pattern generation, fabric cutting, sewing, and ironing/packing. The most critical phase is the sewing phase, Line balancing in apparel industry it is the allocation of sewing machine according to style and design of the garments. Line balancing is levelling the workload across all processes in a line or value stream process to remove bottlenecks and excess capacity. The aims of Line balancing are grouping the resources or labour in an efficient and best pattern in order to obtain an optimum or proper balance of the resources and flows of the production or assembly processes

Therefore proper line balancing technique are used for increasing productivity and efficiency in garment manufacturing while lowering costs to best achievement for company

CHAPTER THREE

METHOD AND MATERIAL

3.1 Research design

This research was designed to analyse and enhancing assembling line in case of Telaje garment manufacturing and sales Plc. Study was first conducted through observation starting from production floor.Telaje garment manufacturing and sales Plc has eight sewing line and four main products types, among this selected one sewing line and one ordered product for the purpose of this thesis work. Then experimental work is performed and then analysed existing scenario of the line. Based on the result obtained the way for improving assembly line of Telaje garment production will be proposed. Both qualitative and quantitative approach methods were used. Collected data were analysed using descriptive statistics for analysis. The obtained results were presented using numerical value and graph.

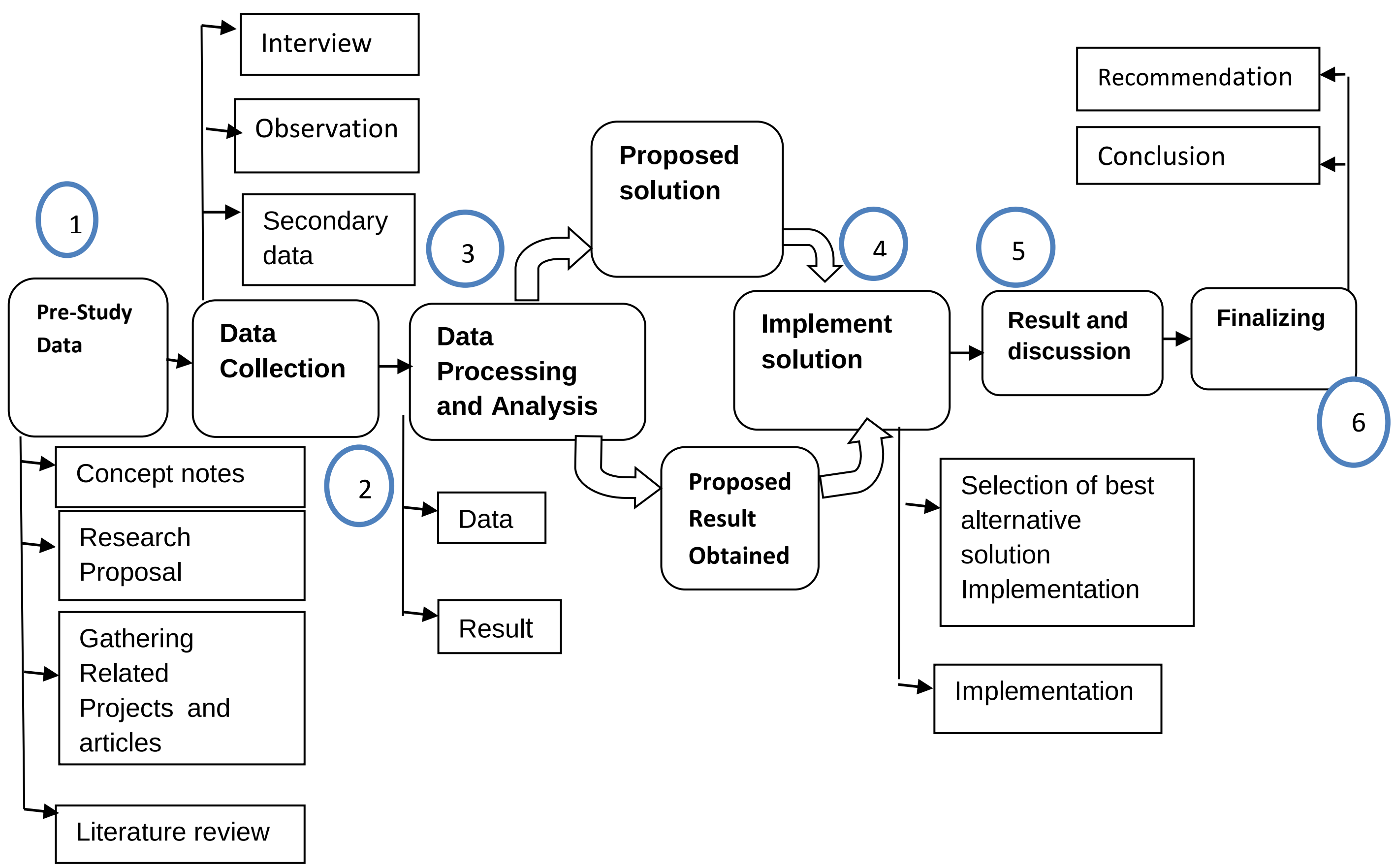

Figure 3.1:-Research work process

3.2 Data collection

The data were collected from Telaje Garment manufacturing and sales plc in garment sewing section .Both primary and secondary data source were used in order to collect relevant data. Primary data was collected from direct observation from production floor and interview for line supervisor and other responsible persons. The data mainly focused on one type of product within the assembling line knows as five pocket men Jeans Trouser. Secondary data were collected through reviewing related literature, different books and journal and different legal documents. For the effectiveness of this study some garment sewing section line balancing calculation include work study, time study and SMV were used with the relation given according to (Noor Ahmed Raaz,2015) as follows

Daily Line Target = (Total working minutes in a day X No. of operators in a line X Line off%)/Garment SAM…………………………………………….…………….(3.1)

Individual operator target = (Total working minutes in a day X line efficiency %)/Operation SAM……………………………………………….…………….(3.2)

Individual operator Efficiency% = (units produced X operation SAM X 100)/Total minutes worked …………………………………………………..…………. (3.3)

Line Efficiency% = (Line output X garment SAM X 100)/ (Number of operators X minute worked in day)……………………………………...……………(3.4)

Note: include helpers and worker doing manual operations in case you have included SAM of those operations.

Machine Productivity: Line output / No. of machine used……….…………….. (3.5)

Machine productivity is measured in production per machine per shift day.

Labour Productivity = Line output / No.of total manpower (operators helpers)……………………………………………………………………….. (3.6)

Standard Time = (Observed time X observed rating) + Allowances………… (3.7)

Allowances – Relaxation allowance, contingency allowance

Machine utilization% = (Actual Machine running Time X 100) / Time available………………………………………………………………………..(3.8)

Cost per minute = Total cost incurred in labour / Total available working minute in a day X no. of labours…………….……………………………..…………..……(3.9)

Production Cost per unit = Total cost incurred in production in a day/ no. of garment produced in a day ………………………………………..…………..….(3.10)

Man to Machine ratio = Total manpower of the factory / Total no. of sewing machines……………………………………………………………………….(3.11)

3.3 Data analysis

For this study among nine lines of the factory one line on the production floor and one garment ordered product which is known us five pockets men's jeans trouser are selected. For the selected product perform operation breakdown based on their style and operational sequences before doing line balance. Working out performance breakdown to compare current factory used method and possible standard method. Examine work measurement to establish the time for a qualified worker to carry out a specified job at a defined level of performance, and also collecting and recording time study to systematic recording and critical examination of existing and proposed ways of doing work. Further Calculation was made for SMV and Efficiency to know time required completing one piece of garment by a qualified (standard) operator at standard condition. Finally for smooth production flow, improve efficiency and productivity, balanced and appropriate line will be proposed with modified line layout.

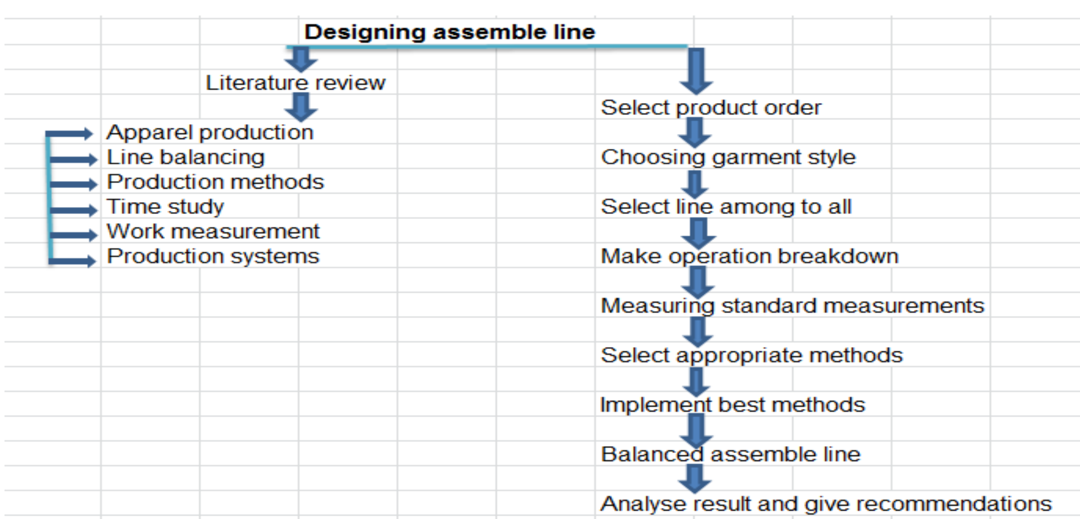

Figure 3.2: general Research work process

3.4 Materials and equipment

For this thesis work the following material and equipment are used as per their required.

Table 3.1 Materials and equipment

S/r No.	Type of equipment	Specification	Location
1	Stopwatch	Standard	Kombolcha
2	Time study format	Standard	Kombolcha
3	Stationary	A4 and Ao paper	Kombolcha
4	Calculator	Scientific	Kombolcha
5	Production sheets	As per factory standard	Kombolcha
6	Daily production report	As per factory standard	Kombolcha
8	Production boards	As per factory standard	Kombolcha

CHAPTER FOUR

RESULT AND DISCUSSION

4.1 Introduction

The quantitative and qualitative research approaches were used in order to collect relevant data. The Qualitative data was collected through direct observation from the production floors in garment sewing section. Quantitative data was conducted interviewing different management level and responsible person. Data were recording and analysis using table and graph using different formulas to calculation in empirical numbers and percentage. For this thesis work the researcher study and analysis three main data, first analysis current company used data as it is given from Industrial engineering department of the company. Secondly analysis current scenario of the factory studied by the researcher who examine and analysis method study and time study to the current garment assembly line in sewing section. Thirdly critically analysis current scenarios of assembly line balance and then implemented proposed solutions on the line to enhance productivity and efficiency.

4.2 Analysis of the existing scenario of the line

In recent day the company try to implement on industrial engineering tools that called line balancing. Company used single model assembly line that means assembly line in which assemblers work on the same product. Machine arrangement and production layout are made based on operational breakdown. Basically the company produce three products known us mean and women jeans trouser, jeans men’s coats and jeans mean shirts. Due to single models production system’s and poor marketing system’s more work load on a particular products even if some line doesn’t work up to a month other line work from Monday up to Sunday without any gap in order to fulfilment delivery date. the Implementations of line balancing in the company is an appreciable but it need frequently asses and improving performance parameter, an operator performance good to accomplish task within the time frame but line efficiency and productivity low this indicate that the line is not properly implement so that it need an improvements. During production process highly wastage of time is present due to bundle allowance, unnecessary movements, poor supervision systems and improper implementation of line.

Table 4.1: line balancing data of the factory

Operation Bulletin for JEANS									
Parameters			No of Inspection Stations Reqd	1					
Output at 100% Eff.		1169	Last Date of Revision	24-Jun-18	No of Sewing Machines	35.4		467.54	
Output (pieces per day)		400	Minutes per Day	480	Total Sewing SAM	18.07			
Target Efficiency		55%	Absenteeism	10%	Total SAM's	23.33			
Line Efficiency (Balancing - Plan)		41%	No Of Operators	44	Total Est AM's	42.42			
No. of Workplaces		48	No Of Helpers/Ironers/Check	4	Pieces per Op /day	9			

The above data has been taken from Telaje garment manufacturing and sales Plc. This data shows that one assembly line from the total production floor with in the factory, the table contain target and current output per day and line efficiency, number of operator and machine, working hour and standard allowable minute’s value.This time study table were recorded and filled by industrial engineering department of the company by using stop watch method but According (Sharmin Akter, Kazi Rezwan Hossain 2017) and (Noor Ahmed Raaz, 2015) and reviewing different related document the above table data and recording observing time on the appendix I data are not compatible. The main reason for inappropriate data were the result of incorrect assign of allowance, rate and motion study, and also calculated and tabulated methods and uses of formula are not correct and valid therefor it need critically investigations and studied line balance data of Telaje garment manufacturing and sales private limited company

Table 4.2: Time study for existing scenario

Assigned	description of operation type of machine	M/c type	No. opr	Cycle time(seconds) 1	2	3	4	5	Aug.	Rating(%)	SAM
A01	O/L Fly Box and Left Fly	3Th o/l	1	32	31	33	30	32	31.6	80	0.53
B	Front										
B01	Attach Side Pkt facing to Pkt Lining	DNLS	1	14	15	13	14	14	14	85	0.25
B02	hem coin pkt	DNLS		12	12	13	12	12	12.2	90	0.23
B03	press coin pkt edge	Iron	1	17	16	17	16	17	16.6	85	0.29
B04	attach coin pkt	DNLS		23	22	21	23	24	22.6	80	0.38
B06	Sew Side Pocket Bag To Front	DNLS	2	38	37	39	36	36	37.2	80	0.63
B07	top s/t side pkt bag	SNLS	1	29	28	27	25	26	27	80	0.46
B08	Run Stich Side Pkt Bag	DNLS	1	19	20	19	21	22	20.2	85	0.36
B09	Tack Side Pkt	SNLS	1	29	29	27	28	26	27.8	80	0.47
B10	Sew Left Front Fly & Edge S/T	SNLS	2	55	54	57	53	55	54.8	75	0.87
B11	J-Stitch	SNLS	1	26	24	24	24	25	24.6	85	0.44
B12	Attach Zipper Right Fly & Fly Box	DNLS	2	53	52	51	51	51	51.6	75	0.82
B13	Front Rise Attach	SNLS	1	43	44	43	42	42	42.8	75	0.68
B14	Top Stich Front Rise	SNLS	1	26	27	25	24	23	25	85	0.45
C	Back										
C01	hem back pkt mouth	DNLS	2	21	23	23	19	26	22.4	80	0.38
C02	sew decoration stitch		1	74	72	73	72	71	72.4	70	1.07
C03	Mark Back Pkt Position	W/Table	1	18	16	15	19	17	17	85	0.31
C04	Attach Bk pkt to back trouser	SNLS	5	125	122	127	119	121	106.4	70	1.58
C05	Attach back yoke & trouser	5TH OL	1	32	30	29	31	30	30.4	85	0.55
C06	top s/t back yoke & trouser	FOA	1	35	34	36	32	35	34.4	80	0.57
C07	Sew Back Rise	5TH OL	1	18	19	21	23	19	20	80	0.33
C08	Top Stich Back Rise	FOA	1	29	27	23	28	27	26.8	80	0.45
D	Assembly										
D01	Sew Inseam	5th ol	1	142	137	144	134	140	139.4	70	2.06
D02	Top Stitch Side Seam	FOA	1	121	128	144	144	144	136.2	70	2.02
D03	Sew Side Seam	5TH OL	1	147	144	140	155	145	146.2	75	2.32
D04	Topstitch waist side	SNLS	1	40	38	34	36	35	36.6	80	0.62
D05	Make Belt Loop	BLM/fdr	1	18	18	19	18	17	18	90	0.34
D06	Mark Belt Loop Position		1	29	26	29	30	26	28	85	0.48
D07	Tack Belt Loop On Waist Body	SNLS	1	51	51	51	53	51	51.4	80	0.86
D08	Waist Band Attach To Body	SNLS	4	215	178	225	218	224	212	75	3.36
D09	Topstitch waist band corner	SNLS	4	427	447	440	448	416	435.6	70	6.45
D10	Bottom Hemming	SNLS	1	51	49	49	52	51	50.4	75	0.8
D11	Make Tack On Fly, Side Pkt	BT	1	39	41	39	40	48	41.4	80	0.7
D12	Trimming			32	34	33	30	33	32.4	85	0.58
D13	Quality Inspection			42	42	43	41	40	41.6	80	0.7
	sum			2122	2087	2146	2141	2121	2123.4	**80**	**33.39**

Where M/C stands machine type, no.opr stands number of operator, Aug stands average. O/l stands overlock.Pkt stands pocket and Bk stands back.

The above data was collected by the researcher using stop watch methods for five cycle time during production process, in some cause this cycle time extended up to fifteen if the recording data have high range. From the table the researcher only work recording observing time and calculated SAM value other such as operation breakdown of five pockets mean jeans trousers, machine types and target output take as it is. The data was collected from each operator during performing each task, the data was recording in seconds by stop watch method, this data is known us observing time, so that in order to assembly five pockets mean jeans trousers 2123.4 seconds observing time is required and 33.39 standard minutes value. From this we understand SAM values of the table approached to standard SAM value of five pockets mean jeans trousers in table1.

Table 4.3: Example to indicate how to calculate and fill the table as follows

Assigned	description of operation type of machine	M/c type	No. Opr	Cycle time(seconds)							SAM
				1	2	3	4	5	Aug.	Rating (%)	
A01	O/L Fly Box and Left Fly	3Tho/l	1	32	31	33	30	32	31.6	80	0.53

Where M/C means machine type, no.opr is number of operator and Aug is average

According (Sharmin Akter, Kazi Rezwan Hossain 2017)

Average time= $\sum_{i=1}^{n} ti/n$

Where Ti=observing time

N=numbers of observing time

Basic Time= (Observed time X Observed rating)/ Standard rating

Standard Minute Value (SMV) = Basic time+ allowances

Efficiency= (per hour production X total SMV)/ (man required X working minute)} X 100%

So that in order to find out average value

Avg =32+31+33+30+32/5=31.6

According to (Noor Ahmed Raaz, 2015)

Allowance= Relaxation on allowance + Contingency allowance + Machine Delay Allowance.

Rating= the pace or speed of operation at which the operator i s performing the job. Standard Minute Value Observed time can be found by the time necessary to complete an operation. This observed time calculated by stop watch. Ratting is an evaluation of Efficiency. This ratting is done by the operator who is performing the job. It can be measured by an observer who experienced in special job which is being observed. Therefore based on operator performance, machine allowance and relaxation allowance the given data are obtained. There for Total allowance is 27% and average rating is 80%

Standard Minute Value (SMV) = Basic time+ allowances

Basic time = (average time/60*rate)

= (31.6/60*80%)

=0.421

Where 31.6 is observing from table 4, 2

SAM value= (basic time) + (basic time*allowance)

= (0.421) + (0.421* 27%)

=0.53

According to (Brian Harrington, 2017) to find out numbers of work stations required are used a simple calculation derived from the "Takt Time" and the "Total Task Cycle Time". The takt time is a calculation for what is required to meet demand.

Takt time = Available working Time/ Customer Demand

Availability working minutes per day =480 minutes and customer demand (from Table 4.1) =400

=480minutes/400units

=1.2 minutes/unit product

=72 second

Each station should at least have a 72 second design cycle time to meet required demand. So that to know numbers of work station as follows

Number of Stations = Total task Cycle Time / Takt Time

Therefore total cycle time =2123.4 Sec and Takt time =72 seconds

Number of Stations =2123.4 /72 =30 workstation

In other way to calculate line efficiency the following data are necessary, the data were collected from production department from Jun, 4, 2018 up to Jun 16, 2018 for 12 production days in appendix table 2 is 184 day/pieces.

According to (Sharmin Akter, Kazi Rezwan Hossain, 2017)

Efficiency= {(per hour production X total SMV)/ (man required X working minute)} X 100%

Where numbers of operator are 44 and garment SAM is 33.39

Efficiency= {(per hour production X total SMV)/ (man required X working minute)} X 100%

$$= \frac{184*33.39*8*100}{44*480}$$

$$\underline{\underline{\mathbf{= 29.1\%}}}$$

In addition it is necessary calculate operator efficiency because efficiency is one of the mostly used performance measuring tools .An operator with higher efficiency produces more garments than an operator with lower efficiency in the same time frame

Operator Efficiency:

According to (Noor Ahmed Raaz, 2015); to calculate the operator efficiency following formula should be followed by any industrial engineer.

$$\text{Operator efficiency (\%)} = \frac{\text{Total minute produced by an operator}}{\text{Total minute attended X 100}}$$

Where, Total minute produced=Total piece made X Average SAM of the operation, so that Total minute produced=184 *1.020833

=187.833

<u>Where</u>1.020833 is average SAM from the Table 4.1

Total minutes attended=Total hours worked in the machine X 60

= 8hr X 60

= <u>480 min</u>

$$\text{Operator Efficiency\%} = \frac{\text{Total minute produced by an operator *100}}{\text{Total minute attended by operator}}$$

$$= \frac{187.833 * 100}{480}$$

$$= \underline{38.13\%}$$

Process time

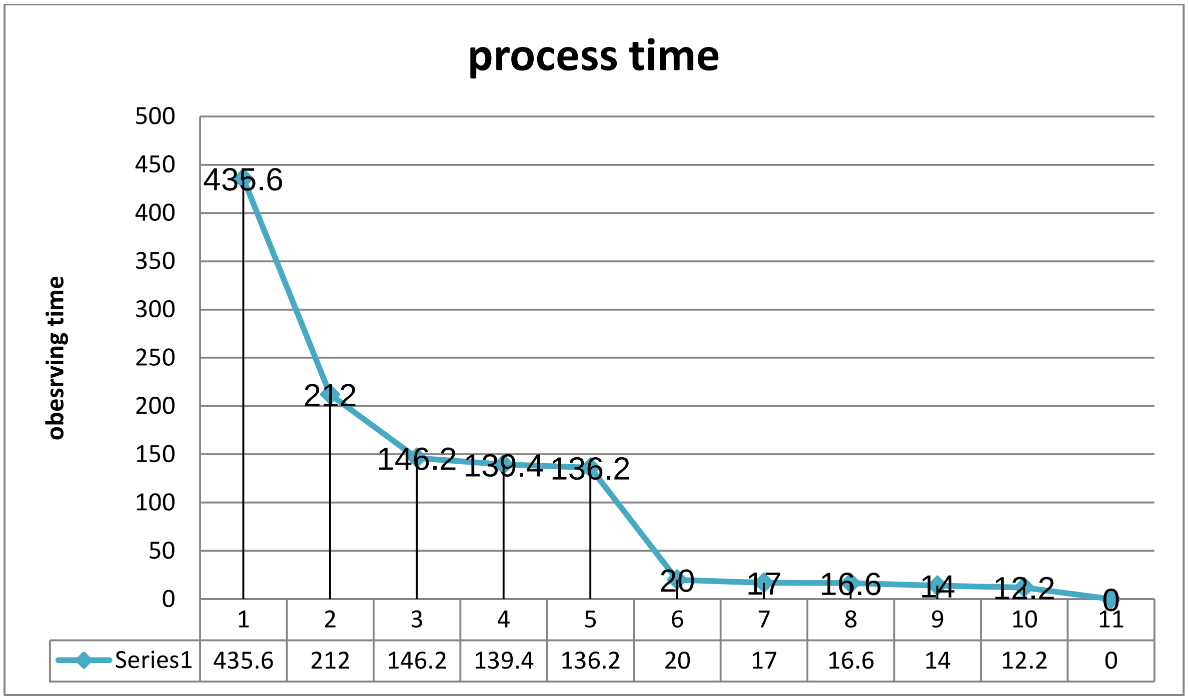

Figure 4.1: process time

Work measurement refers to the estimation of standard time for an activity that is time allowed for completing one pieces of job by using prescribe methods. General principle that governs cycle time are greater accuracy desired in the results, larger should be the numbers of cycle observed, study should be continued through sufficient number of cycles and where more than one operator is doing the same job ,short study(say 10 to 15 cycles)should be conduct on each of the several operators than one long study on single operator so that based on this guiding principle The researcher observes and record individual operator cycle time to perform each task to be assigned .The graph indicate maximum and minimum observing time of 10 operator. first five observing time indicate high time taken operation and second five operation are low operation time taken .

Pitch time diagram

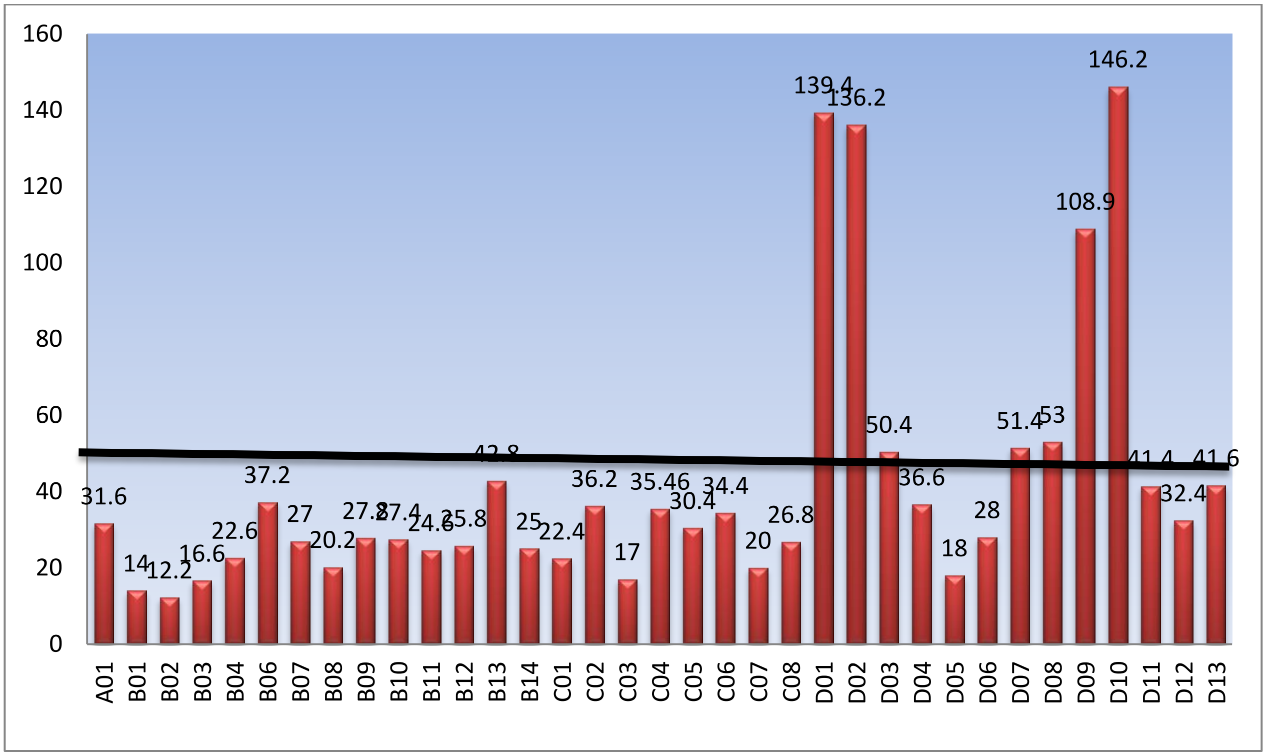

Figure 4.2 Pitch time diagram

According to (Prasanta Sarkar Nov 7, 2011)

Pitch time: In industrial Engineering, Pitch time is a ratio of total SAM of garment and number of operations to be set for the style. Pitch time is used for line setting and calculating production target for the line. Graphical presentation of individual operation's time and pitch time on a same chart is called pitch diagram. At this chart on X-axis operation assigned name and on Y-axis time value is depicted. First conduct a capacity study for all operators and find out how many pieces operators are making at each operation. Based on this information calculated existing scenario of pitch time is mandatory for assembly line balancing.

$$\text{Basic pitch time} = \frac{\text{Net process time}}{\text{Total number of operator}}$$

$$= \frac{2123.4}{44}$$

$$= \underline{\underline{48.259}}$$

Control limits

Upper limit= $\frac{\text{pitch time} * 100}{\text{Target organization efficiency}}$

Lower limit= 2*pitch time-upper limit

: - Where pitch time referee value for synchronization in the division of labour it provides average time allotted to each worker

Pitch time =48.259

Target organization efficiency=55%

Upper limit= $\frac{48.259*100}{55}$

=87.74seconds

Lower limit= 2*pitch time-upper limit

=2*48.259-87.74

=8.778 seconds

From this we understand assigned of task to an operator are not equal distribute of work load because the upper limit and lower limit have highly range so that it need to minimize this gape in order to equal work distribution based on operator skill matrix and improve productive

Table 4.4: Highly Bottleneck Operation in the Existing Scenarios

Assigned no	description of operation	M/c type	Existing M/C and Opr.	Existing Line Output	Existing Balance Efficiency	Proposed M/C and Opr.	Proposed Line Output	Proposed Balance efficiency
D01	Sew Inseam	5th ol	1	184	29.1%	2	387pices/ day	50.04%
D02	Top Stitch Side Seam	FOA	1	184	29.1%	2	387pices/ day	50.04%
D08	Waist Band Attach To Main Body	SNLS	2	184	29.1%	6	387pices/ day	50.04%
D09	Topstitch waist band corner	SNLS	2	184	29.1%	6	387pices/ day	50.04%

Where no stands number, opr stands operation and M/C stands machine

Bottleneck processes are a delay in transmission that slow down the production rate. This can be overcome by balancing the line. From the above pitch diagram and line capacity graph we understand that workers having lower capacity level are doing their jobs at operation such as Sew Inseam, Top Stitch Side Seam, Waist Band Attach To Main Body and Topstitch waist band corner are take more time that cross upper control Limit (UCL) and it is approximately 87.74seconds. They require more processing time for which cannot pass required amount of product to the next operator or next operation. These positions are creating bottlenecks. On the other side Not any operators were doing the jobs more promptly than the requirement. So this indicates the line was imbalance. Work load is excess that was distributed among the higher capacity possessing workers considering the layout. Thus the bottlenecks were solved and maximum capacity was utilized and most importantly productivity was improved. Finally minimize thus bottleneck process and increasing line productivity and total line efficiency enhancing up to 50.04%.

Problem of the existing scenario

- ✓ Lack of Use of work aids, attachments, guides, correct pressure foots and folders:-These are some kinds of time saving devises that facilitate operator to perform their work effectively with less effort. If work aids are used effectively operation cycle time can be reduced many fold than existing cycle time. So that the main problem in Telaje garment manufacturing is Use of work aids and attachments is insufficient due to no experienced technical person (maintenance, IE personnel or production manager) generally not aware about the usage and availability of work aids
- ✓ Lack of training for Line supervisors and sewing operators;-Each supervisor must be trained with fundamental management skills and communication skill and also it need supervisor should understand the fundamental technical skill like operation bulletin, skill matrix, workstation layout, movement, capacity study and theoretical line balancing etc. Operators are main resources in the apparel manufacturing. They are most valuable resource to the company. So, factory must work on developing operator skill where required. Due to much reason like poor understanding of different responsible person, lack

of resource and afraid of incurred cost due to training the factory does not offered training to an operator and supervisors this affected directly for product quality and productivity

- ✓ Production system: - The Telaje garment manufacturing and sales PLC us progressive bundle system. This system was bundles of garment parts that are moved sequentially from operation to operation. This system often referred to as the traditional production system, has widely used by apparel manufacturers .this system may require a high volume of work in process because of the number of units in the bundles and the large buffer of backup work that is needed to ensure a continuous workflow for all operators due to this Telaje garment production more ideal time tie and re tied this bundle this affect production time and efficiency.
- ✓ Minimum production capacity: - Hourly and daily production capacity of an operator and total line capacity is low as compare to theoretical production of the company,. The actual production capacity of the line per a day is 184pices but the expected capacity of the line per day is 400 so that this indicates that large variances between actual productions with settled production capacity.
- ✓ Not suitable work place:- in Telaje garment production floor is not suitable to an operator due to high humidity the company doesn't
- ✓ Line Layout problem:-Telaje garment manufacturing and seals PLC use straight assembly line balancing this Line layout was placing of machines and centre table in production flower. The main purpose of choosing better layout is to reduce transportation time in the line as much as possible, but the current scenario of selected line was two lines with singe product production this lead increase ideal time and transportation time so that to reduce this problem it should be implement scientific workstation layout.
- ✓ Conduct Research and development for the garment: - A non-value added process but having a strong Research and Development team in the factory brings a lot of benefits. Based on the give data of the factory and searching some information about this team it is not play vital role to the factory specially with relate line balancing for example the factory have a data with

relate to industrial engineering is recent date even if line efficiency is below 30% but have not work an research to improve performance of the line.

Proposed line Operational procedure for selected style

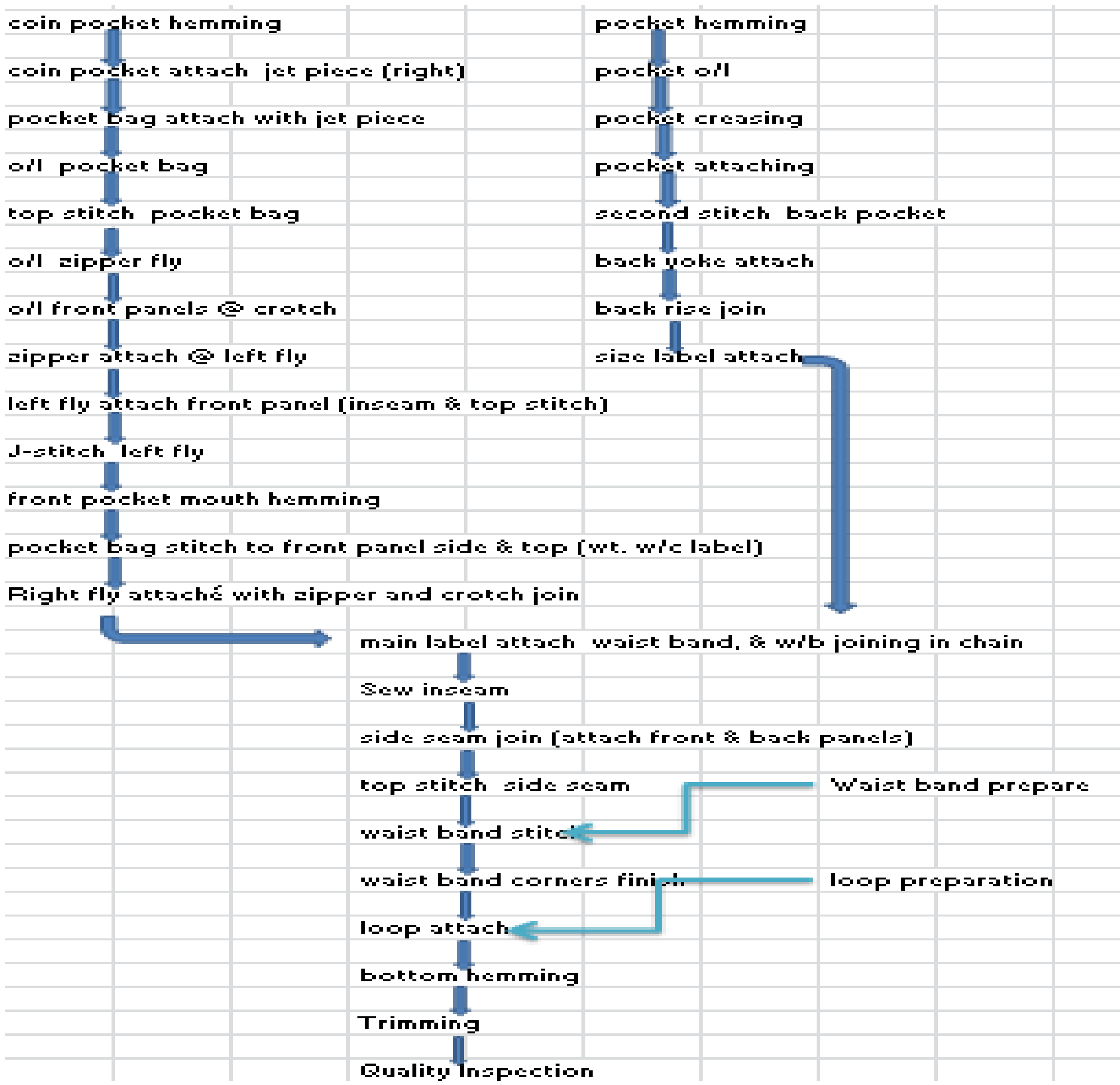

Figure 4.3: Proposed line Operational procedures

The operation breakdown of five pocket jeans trouser has two front pocket and two back pockets and one coin pocket .from the above figure we understand front and back panel prepare separately and assemble when the two panel finish and come join together. Some part like waist band preparation and loop preparation are intimidated process rather than the main production. This operational process is best and more compatible with factory machine and operator.

Table 4.5: Sequential relationships among tasks and draw a precedence table

No	Operation	Machine type	Precedence
1.	coin pocket hemming	DNLS	-
2.	pocket hemming	DNLS	-
3.	coin pocket attach jet piece (right)	DNLS	1
4.	pocket o/l	3T O/L	-
5.	pocket bag attach with jet piece	DNLS	3 & 1
6.	pocket creasing	ADPC	-
7.	o/l pocket bag	ST O/L	-
8.	pocket attaching	SNLS	2,4 & 6
9.	top stitch pocket bag	SNLS	5 & 3
10.	second stitch back pocket	SNLS	8
11.	o/l zipper fly	3T O/L	-
12.	back yoke attach	ST O/L	-
13.	o/l front panels @ crotch	3T O/L	-
14.	back rise join	ST O/L	12
15.	zipper attach @ left fly	DNLS	11
16.	size label attach	SNLS	-
17.	left fly attach front panel (inseam & top stitch)	SNLS	-
18.	J-stitch left fly	SNLS	15
19.	front pocket mouth hemming	DNLS	-
20.	pocket bag stitch to front panel side & top (wt. w/c label)	SNLS	5,7 & 9
21.	Right fly attaché with zipper and crotch join	SNLS	-
22.	main label attach waist band, & w/b joining in chain	SNLS	-
23.	Sew inseam	FOA	17
24.	side seam join (attach front & back panels)	5T O/L	-
25.	top stitch side seam	ST O/L	24
26.	Waist band prepare	SNLS	-
27.	waist band stitch	SNLS	23
28.	waist band corners finish	SNLS	27
29.	loop preparation	BLM/fdr	-
30.	loop attach	SNLS	22
31.	bottom hemming	BHM	
32.	Trimming		
33.	Quality Inspection		

The above table indicate an operational procedure's and Precedence of an operation in five pocket trouser. These indicate that the product can't be move to the next station if it doesn't complete at the previous station. This precedence operation made based on standards operational procedure and operational breakdowns with the existing production method of the factory.

Table 4.6:-Proposed operational breakdown and SAM values

Sl. no.	Operations	M/C Type	Manpower	Avg.basic Time(seconds)	SMV
Front					
1.	coin pocket hemming	DNLS	1	14	0.23
2.	coin pocket attach jet piece (right)	DNLS	1	29	0.47
3.	pocket bag attach with jet piece	DNLS	1	38	0.62
4.	o/l pocket bag	3T O/L	1	21	0.35
5.	top stitch pocket bag	SNLS	1	23	0.37
6.	o/l zipper fly	3T O/L	1	14	0.23
7.	o/l front panels @ crotch	3T O/L	1	15	0.25
8.	zipper attach @ left fly	DNLS	1	31	1.0
9.	left fly attach front panel (inseam & top stitch)	SNLS	1	50	0.8
10.	J-stitch left fly	SNLS	1	19	0.32
11.	front pocket mouth hemming	DNLS	1	16	0.41
12.	pocket bag stitch to front panel side & top (wt. w/c label)	SNLS	1	37	0.6
13.	right fly attach with zipper & crotch join	SNLS	1	47	0.76
Back					
14.	pocket hemming	DNLS	1	28	0.46
15.	pocket o/l	ST O/L	1	13	0.22
16.	pocket creasing	ADPC	1	16	0.27
17.	pocket attaching	SNLS	4	105	1.77
18.	second stitch back pocket	SNLS	1	17	0.28
19.	back yoke attach	ST O/L	1	120	1.94
20.	back rise join	ST O/L	1	32	0.53
21.	size label attach	SNLS	1	23	0.38
Assembly					
22.	main label attach waist band, & w/b joining in chain	SNLS	3	186	3.1
23.	Sew inseam	FOA	2	39	0.65

……….Continued…….

24.	side seam join (attach front & back panels)	5T O/L	1	33	0.8
25.	top stitch side seam	ST O/L	2	51	0.85
26.	Prepare waists band	SNLS	1	48	0.81
27.	waist band stitch	SNLS	6	189	3.15
28.	waist band corners finish	SNLS	6	244	4.07
29.	loop preparation	BLM/fdr	1	97	1.27
30.	loop attach	SNLS	1	45	0.75
31.	bottom hemming	BHM	1	123	2.05
32.	Trimming		1	35.7	0.59
33.	Quality Inspection		1	40.1	0.68
	Total		50	1838.8	31.03

Where Sl. no. stands serial number, Avg stands average and M/C stands machine

The above table and data somehow it is different from the existing data in operational breakdown and sequence. Those data work on based on preceding diagram and standard operational sequence of five pocket jeans men trouser. Observed Data are recorded by the researcher by using of stop watch methods and same calculated method from the above.As the same from table 4.1 According to (Brian Harrington 2017) to find out numbers of work stations required:

Takt time = Available working Time/ Customer Demand

Availability working minutes per day =480 minutes and customer demand =418

=480minutes/418units

=1.148 minutes/unit product

=69 second

Each station should at least have a 69 second design cycle time to meet required demand. So that to know numbers of work station as follows

Number of Stations = Total task Cycle Time / Takt Time

Therefore total cycle time =1838.8 Sec and Takt time =69 seconds

Number of Stations =1838.8 /69 =27 workstation

Production estimation

Estimation Daily production = Total man minutes available in a day/SAM * Average Line efficiency

So that, total number of operators=50, total minutes available =480 minutes/day, SAM =31.03 and according to (KARUNA SINGH 2016) line efficiency is 50% for calculated estimation production

Total available man-minutes =Total no. of operators X Working hours in a day X 60

=50*480 minutes=24000mintus

So Estimation Daily production = Total man minutes available in a day/SAM * Average Line efficiency

Estimation Daily production=24000*50/31.03*100

1296000

3103

=387pices/day

Where 31.03 SAM value from table 4.5

Line Efficiency% = (Line output X garment SAM X 100)/ (Number of operators X minute worked in day)

= 387*31.03*100

50*480

= 50.04%

As comparing the existing scenario and proposed data based on rate, basic time, SAM value target and total capacity are analysis as follows. In existing scenario it gives 90% of rating but based upon operator experience, Fluid motions, coordination and wasted actions this data is more exaggerated so that proposed rating is 80% within the line. Average basic time for the existing scenario are not properly recording and the proposed average basic time is 1838.8 second by reducing un necessary movements of operator and batter working methods. Due to incorrect recording of basic time, tabulated and calculation problem and assign of allowance the existing scenario of SAM value is 23.33 but to properly calculated based on the data assign by the factory is 33.39 but the proposed line data SAM value are 31.03 finally based on the above data proposed line target output per day is 387 and per hour 48 and line efficiency are 50.04**%.**

According to (Prasanta Sarkar Nov 7, 2011) to calculate Pitch time in the proposed scenario.

$$\text{Basic pitch time} = \frac{\text{Net process time}}{\text{Total number of operator}}$$

$$= \frac{1838.8}{50}$$

$$= 36.776$$

According to (Noor Ahmed Raaz, 2015); to calculate Operator efficiency

$$\text{Operator efficiency (\%)} = \frac{\text{Total minute produced by an operator} * 100}{\text{Total minute attended X 100}}$$

Where, Total minute produced=Total piece made X Average SAM of the operation so that Total minute produced=387*0.9403

$$= 363.8961$$

Where 0.9403 is Average SAM of the operation from Table 4.5:-

Total minutes attended=Total hours worked in the machine X 60

$$= 8\text{hr X } 60$$

$$= 480 \text{ min}$$

$$\text{Operator Efficiency\%} = \frac{\text{Total minute produced by an operator} * 100}{\text{Total minute attended by operator}}$$

$$= \frac{363.8961 * 100}{480}$$

$$= 75.81\%$$

Production Cost for five pockets trouser

In the daily production report many companies include actual garment production cost from the given a style. In this study production cost represents sewing room cost and is taken to identify the cost of each situation. Therefore all direct and indirect cost who are connected to garment sewing and managing sewing line are considered in the calculated in garment production cost. Based on Telaje garment manufacturing and seals PLC production manager handles eight lines monthly salary is 8500:00 birr considered as cost incurred per line per day by dividing number of line.

$$\text{Machine depreciation} = \frac{\text{M/C purchasing cost}}{\text{Estimate service life}}$$

So that to calculate machine deprecation it gives average price of machine is 16000ETB and estimate service life of the machine is 10 years,so deprecation for one day

$$= \frac{16000birr}{10year*12month*26\ day}$$

=4.1birr,

Where; 26 are working days in a month.

If the rent of the house is 60,000birr/month, so that rent of per day is

= 60000birr/26day=2307.69birr.

In order to get one line among eight divided by eight it gives 288.46birr.

Expense per month 12,000birr; for one day it divided number of working day .working day per month is 26 so that it gives 461.538birr; for one line 57.69birr

Actual garment production cost of five pocket trouser is sum of the cost incurred for direct cost and indirect cost

Table 4.7 production cost of trouser the excising and proposed line scenario

No	Employee designation	Daily salary	Number of employees	Total daily salary(etb)
1	Manager	461.53	1	461.53
	Designer	326.92	2	653.92
2	Production manager	326.92	1	326.92
2	Line supervisor	276.92	1	276.92
3	Maintenance	84.65	2	169.3
4	quality control	84.65	1	84.65
5	Recorder	69.23	1	69.23
6	Bundle transporter	69.23	2	138.46
7	Operators	69.23	44	3046.12
8	Helper	69.23	4	276.92
9	Expense	57.69birr		57.69
10	Depreciation	4.1birr	44machine	184.4
10	Rent	288.69birr	.33	288.46
Total				6034.52Birr/day
	Existing line daily production cost per picess	pcs daily output184	Daily production cost = $\frac{\text{Total cost/day}}{\text{daily output/pcs}}$ $\frac{6034.52}{184}$ 32.796Birr/pcs	6034.52
	Proposed line	Daily product=220.375pcs	Daily production cost = $\frac{\text{Total cost/day}}{\text{daily output/pcs}}$ $\frac{6470.5}{387}$ =16.72Birr/pcs	6470.5

Proposed line layout

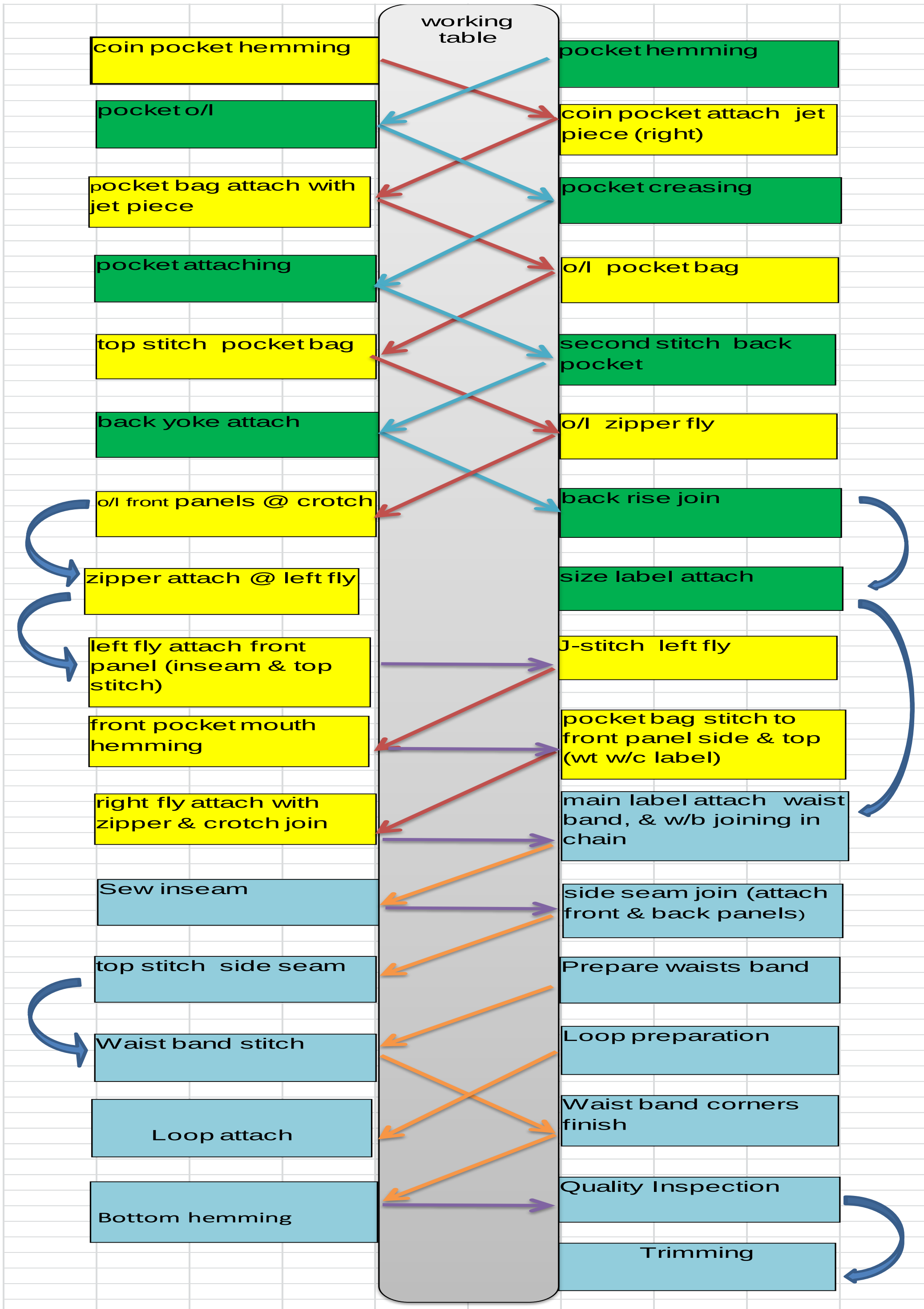

Figure 4.4:-proposed line layout

The above graph shows that assembly line for proposed line layout. From the graph yellows shade indicate front panel in five pocket trouser, green shads indicate back panel and blue shades indicate assembly operation. The middle is working table and the arrows indicate operation procedure and production follows. The existing line layout of the factory are used two separate place that means front panel and assembly operation in a single line and back panel work different line to assemble single product this affect proper flows of material, material delay, unnecessary movement of an operator, reduce rate, not meet target output per day and finally decrease line efficiency and productivity but the proposed line solve those problem and increase line efficiency and meet target output .in the other way the existing line accommodate 48 operator with helper and new proposed layout accommodate 54 operator with single line this helps To maximize the utilization of floor space and minimize the material handling and transportation.

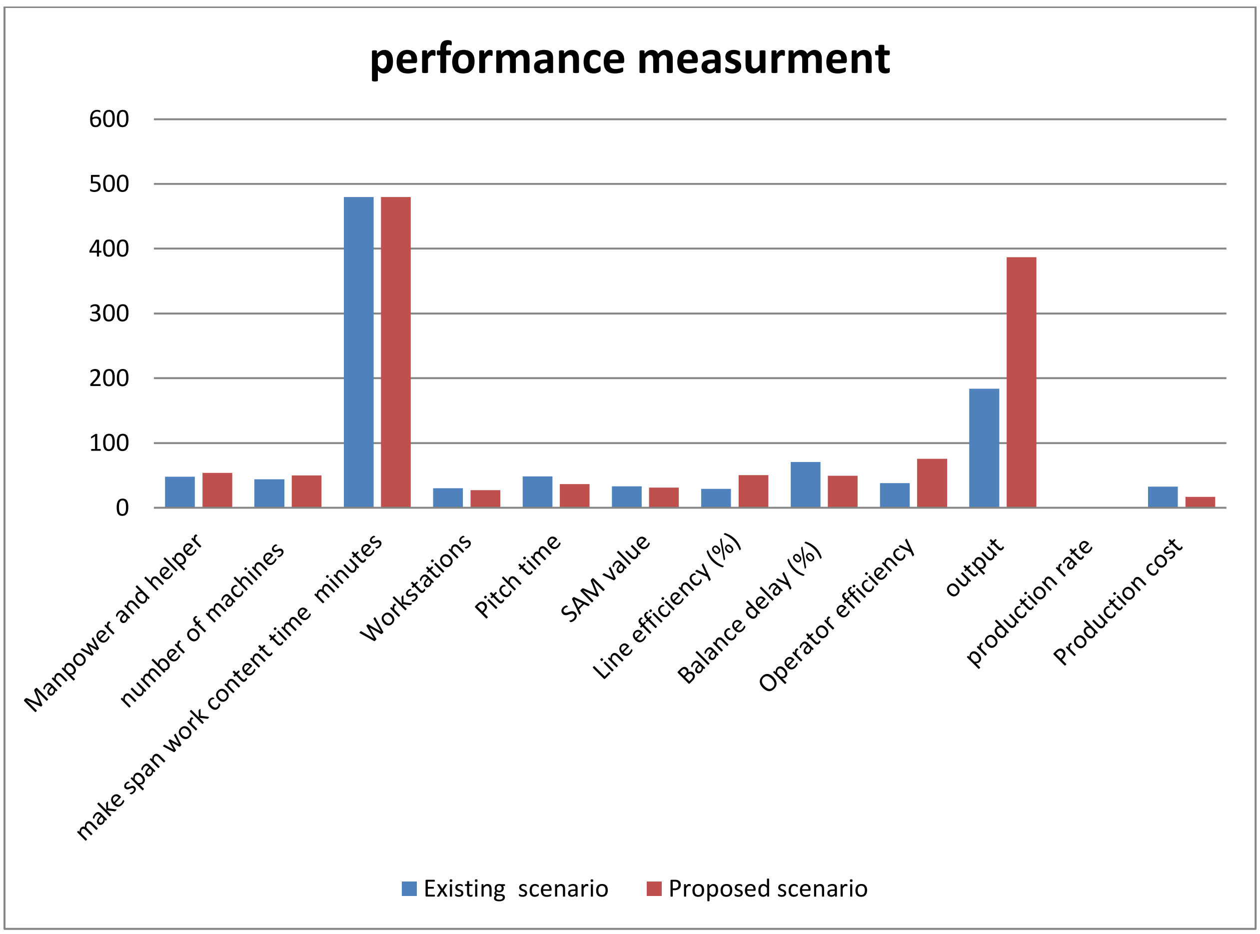

Figure 4.5 performance measurement

From the above figure existing and proposed scenario of the line performance result were obtained as a summary, SAM value were decreased from existing scenario to proposed scenario from 33.39 to 31.03 this implies that the average amount of time required to complete a specific job or operation under existing condition would be decrease so that operator performance and production system would be improved in the proposed scenario of the line. Based on implementing modified line total work station, pitch time, production cost per pieces and balance delay will be decrease; this is an achievement to the indication of improvements sewing section. Daily output of a line will increase from 184 pieces per day to 387 pieces per day, and in order to minimize bottleneck area and balanced a line increase 6 number of operator for the proposed line and machine from 44 to 50 from the existing scenario. Finally line efficiency will increased from 29.1% of the existing scenario of line to 50.4% for the proposed line.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 conclusions

This study on improving assembly line balancing inTelaje garment manufacturing and sales private limited company to improve productivity and efficiency of a line. Properly balanced assembly line in apparel industry is a very important and crucial issues in order to enhance utilization of resource.This thesis work analysis the current situation with relate to assembly line and developed proposed line to improve key performance parameter such as line efficiency, productivity and production cost by reducing and eliminating the problem of existing scenario of the line based on this proposed scenario was improving efficiency from 29.1% to 50.04%,productiveity from 184 pieces/day to 387 pieces/day and production cost was minimize from 32.796 cost per pieces(ET birr) to16.72 cost per pieces(ET birr).Therefore this thesis work improved assembly line in all aspects especially productivity and efficiency of the company.

5.2 Recommendation

From the finding of this thesis work the researcher recommended some basic issues as follows

- ✓ In order to improve production rate and quality of product work aide should be used in production process
- ✓ Human resource department and other responsible should be continuously check performance of an operator and offered training to have skill gap.
- ✓ Assigned helper must have multi task skill rather that layman or poor performance operator
- ✓ The company having ideal time of machine and operator due to lack of ordered product so that the responsible person and department must be searching market

- ✓ A company research and development team should be continuously work with relate to assembly line balancing and create cleared image about line balancing and continuously modified line to improve productivity and efficiency.
- ✓ Company working place is not suitable to an operator due to high humidity of the kombolcha city therefor it need to apply cooling system within the company.

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APPENDEX I

Bahir Dar University

Ethiopia Institution of Textile and Fashion Technology

Department of garment technology

Time study for the existing scenario of Factory

s.no.	Operation	observed time	SAM	m/c & oper.	est. time	M/C type	folder / attachments	M/P calculate	m/P allotted	m/C allotted
A	**Parts Preparation**									
A01	O/L Fly Box	41.04	0.57	Y	1.04	3 Th O/L		0.86	1.0	
A02	Over Lock Left Fly									
A03	serge side pkt facing									
A04	serge front rise									
B	**Front Trouser**									
B01	Attach Side Pkt facing to Pkt Lining	25.20	0.35	Y	0.64	DNLS		0.53	1.0	
B02	hem coin pkt	7.92	0.11		0.20	DNLS		0.17		
B03	press coin pkt edge	18.72	0.26		0.47	Iron		0.39		1
B04	attach coin pkt	18.72	0.26		0.47	DNLS		0.39	1.0	
B05	attach pkt facing on pkt bag	38.88	0.54		0.98	DNLS		0.82	1.0	
B06	Sew Side Pocket Bag To Front	37.44	0.52	Y	0.95	SNLS		0.79	1.0	
B07	top s/t side pkt bag	49.68	0.69		1.25	DNLS		1.05	1.0	
B08	Run Stich Side Pkt Bag	18.72	0.26	Y	0.47	DNLS		0.39	1.0	
B09	top s/t side pkt bag	59.76	0.83	Y	1.51	SNLS		1.26	1.0	
B10	Tack Side Pkt	37.44	0.52	Y	0.95	SNLS		0.79	1.0	
B11	Sew Left Front Fly & Edge S/T	64.08	0.89	Y	1.62	SNLS	CL(1/16")	1.35	1.0	
B12	J-Stitch	23.76	0.33	Y	0.60	DNLS		0.50	1.0	
B13	Attach Zipper To Right Fly And Fly Box	65.52	0.91	Y	1.65	SNLS	zipper foot	1.38	1.0	
B14	Front Rise Attach	50.40	0.70	Y	1.27	SNLS		1.06	1.0	
B15	Top Stich Front Rise	30.96	0.43	Y	0.78	DNLS		0.65	1.0	
C	**Back Section**	0.00								
C01	hem back pkt mouth	25.20	0.35	Y	0.64	DNLS		0.53	1.0	
C02	sew decoration stitch	82.80	1.15	Y	2.09			1.74	2.0	
C03	Mark Back Pkt Position	45.94	0.64	H	1.16	w.table		0.97		1
C04	Attach Bk pkt to back trouser	123.12	1.71	Y	3.11	SNLS	CL(1/16")	2.59	3.0	
C05	Attach back yoke & trouser	30.96	0.43	Y	0.78	5th ol		0.65	1.0	
C06	top s/t back yoke & trouser	67.68	0.94	Y	1.71	FOA		1.42	1.0	
C07	Sew Back Rise	21.17	0.29	Y	0.53	5th ol		0.45	1.0	
C08	Top Stich Back Rise	45.36	0.63	Y	1.15	FOA		0.95	1.0	

……….continued………….

D	Assembly	0.00								
D01	Sew Inseam	62.64	0.87	Y	1.58	5th ol		1.32	2.0	
D02	Top Stitch Side Seam	124.56	1.73	Y	3.15	FOA		2.62	2.0	
D03	Sew Side Seam	49.68	0.69	Y	1.25	5th ol		1.05	2.0	
D04	Topstitch waist side	46.80	0.65	Y	1.18	SNLS	25/8''f	0.98	1.0	
D05	Make Belt Loop	17.28	0.24	Y	0.44	BLM f		0.36	1.0	
D06	Mark Belt Loop Position	31.10	0.43	H	0.79	w.table		0.65		1
D07	Tack Belt Loop On Waist Body	20.88	0.29	Y	0.53	SNLS		0.44	1.0	
D08	Waist Band Attach To Main Body	56.16	0.78	Y	1.42	SNLS	25/8''fo	1.18	2.0	
D09	Topstitch waist band corner	62.64	0.87		1.58	SNLS		1.32	2.0	
D10	Bottom Hemming	34.56	0.48	Y	0.87	SNLS	2''hem. Fo	0.73	2.0	
D11	Make Tack On Fly, Side Pkt	37.80	0.53	Y	0.95	BT		0.80	1.0	
D12	Quality Inspection	43.20	0.60	I	1.09	w.Tabl		0.91		1
D13	Trim thread	62.10	0.86	H	1.57	w.table		1.31		
	Total sewing SAM		**18**		**32.8**			**35.4**	**44**	**4**
	Total SAM	**45.40**	**23.3**		**42.4**		`			**48**

APPENDEX II

Bahir Dar University

Ethiopia Institution of Textile and Fashion Technology

Department of garment technology

Existing Production capacity of the factory from Jun-4-2018 to jun-16-2018

Production date	Total out put	Total manpower	Production minutes
Monday- Jun -4-2018	0	48	480
Tuesday- 5-jun-2018	0	48	480
Wednesday- 6 -jun-2018	245	48	480
Thursday- 7 -jun-2018	261	48	480
Friday – Jun- 8-2018	261	48	480
Saturday jun-9-2018	133	48	480
Monday -Jun -11-2018	214	48	480
Tuesday- 12- jun-2018	241	48	480
Wednesday- 13 -jun-2018	287	48	480
Thursday- 14- jun-2018	217	48	480
Friday- jun-15-2018	228	48	480
Saturday- jun-16-2018	111	48	480

APPENDEX III

Bahir Dar University

Ethiopia Institution of Textile and Fashion Technology

Department of garment technology

Performance measurement comparison

No.	Performance indicator	Existing scenario	Proposed scenario
1	Manpower and helper	48	54
2	number of machines	44	50
3	make span work content time minutes	480	480
4	Workstations	30	27
5	Pitch time	48.259	36.776
7	SAM value	33.39	31.03
8	Line efficiency (%)	29.1	50.4
9	Balance delay (%)	70.9	49.6
10	Operator efficiency	38.13	75.81
11	output (p) per 8 hour	184	387
12	production rate(Rp)=P/480min	0.38	0.806
13	Production cost per pieces(ET birr)	32.796	16.72

Where no is numbers and ET birr is Ethiopian birr.

APPENDEX IV

Bahir Dar University

Ethiopia Institution of Textile and Fashion Technology

Department of garment technology

Pitch time and capacity measurement

Assigned	description of operation type of machine	M/c type	No. opr	Avg	SAM	Basic pitch time	Target output/hr	Balancing	Operator capacity/hr	Operator efficiency
A01	O/L Fly Box and Left Fly	3Th o/l	1	31.6	0.53	31.6	113	23.89	1.64	20.32
B	Front									
B01	Attach Side Pkt facing to Pkt Lining	DNLS	1	14	0.25	14	240	11.25	4.286	9.58
B02	hem coin pkt	DNLS	1	12.2	0.23	12.2	261	10.34	4.918	8.82
B03	press coin pkt edge	Iron		16.6	0.29	16.6	207	13.04	3.61	11.12
B04	attach coin pkt	DNLS		22.6	0.38	22.6	158	17.09	2.65	14.57
B06	Sew Side Pocket Bag To Front	DNLS	1	37.2	0.63	37.2	95	28.42	1.61	24.15
B07	top s/t side pkt bag	SNLS	1	27	0.46	27	130	20.77	2.22	17.63
B08	Run Stich Side Pkt Bag	DNLS	1	20.2	0.36	20.2	167	16.17	2.97	13.8
B09	Tack Side Pkt	SNLS	1	27.8	0.47	27.8	128	21.09	2.15	18.02
B10	Sew Left Front Fly & Edge S/T	SNLS	2	54.8	0.87	27.4	138	19.56	2.19	33.35
B11	J-Stitch	SNLS	1	24.6	0.44	24.6	136	19.85	2.44	16.87
B12	Attach Zipper Right Fly & Fly Box	DNLS	2	51.6	0.82	25.8	146	18.49	2.32	31.43
B13	Front Rise Attach	SNLS	1	42.8	0.68	42.8	88	30.68	1.402	26.07
B14	Top Stich Front Rise	SNLS	1	25	0.45	25	133	20.3	24	17.25
C	Back									
C01	hem back pkt mouth	DNLS	1	22.4	0.38	22.4	158	17.09	2.68	14.57
C02	sew decoration stitch		2	72.4	1.07	36.2	112	53.57	1.65	41.02
C03	Mark Back Pkt Position	W/Table	1	17	0.31	17	194	13.9	3.53	11.88
C04	Attach Bk pkt to back trouser	SNLS	3	106.4	1.58	35.46	114	23.68	1.69	60.57
C05	Attach back yoke & trouser	5TH OL	1	30.4	0.55	30.4	109	24.77	1.97	21.08
C06	top s/t back yoke & trouser	FOA	1	34.4	0.57	34.4	105	25.71	1.74	21.85
C07	Sew Back Rise	5TH OL	1	20	0.33	20	181	14.9	3	12.65
C08	Top Stich Back Rise	FOA	1	26.8	0.45	26.8	133	20.30	2.23	17.25
D	Assembly									
D01	Sew Inseam	5th ol	1	139.4	2.06	139.4	29	93.1	0.43	78.97
D02	Top Stitch Side Seam	FOA	1	136.2	2.02	136.2	30	90	0.44	77.43
D03	Sew Side Seam	5TH OL	1	50.4	0.8	50.4	75	36	1.19	30.67
D04	Topstitch waist side	SNLS	1	36.6	0.62	36.6	97	27.83	1.64	23.77

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D05	Make Belt Loop	BLM/fdr	1	18	0.34	18	176	15.34	3.3	13.03
D06	Mark Belt Loop Position		1	28	0.48	28	125	21.6	2.14	18.4
D07	Tack Belt Loop On Waist Body	SNLS	1	51.4	0.86	51.4	70	38.57	1.167	32.97
D08	Waist Band Attach To Body	SNLS	4	212	3.36	53	71	38.03	1.132	128.8
D09	Topstitch waist band corner	SNLS	4	435.6	6.45	108.9	37	72.97	0.55	247.25
D10	Bottom Hemming	SNLS	1	146.2	2.32	146.2	27	100	0.41	88.93
D11	Make Tack On Fly, Side Pkt	BT	1	41.4	0.7	41.4	86	31.39	1.44	26.83
D12	Trimming		1	32.4	0.58	32.4	103	26.21	1.85	22.23
D13	Quality Inspection		1	41.6	0.7	41.6	86	31.39	1.44	26.83
Sum				2123.4	**33.39**	1460.96			94.057	

Where M/c stands machine, No.opr stands number of operator, Avg stands average and hr is hour