

PRODUCTIVITY IMPROVEMENT IN GARMENT FACTORY
(Case in Candy & Helen Garment Factory)

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ABSTRACT

This main concern of this study is to improve the productivity of the factory by LEAN approach. The purpose of lean in production is to increase productivity, improve product quality, reduce lead time and eliminate manufacturing waste. The study has been conducted on C&H Garment factory that produces different men's and women's garment products, located in Bole Lemmi industry park Addis Ababa.

On an earlier stage, a literature review on lean was conducted, from the creation of the concept of LEAN to its main tools and techniques. Valuable data has been collected from the case study (C&H Garment Company) by observation, and interview from management body. The collected data has been analyzed according to the relevant time. For this purpose MS-excel, statistical tools, MS-Visio have been applied; in addition to these, industrial or lean tools were considered.

The research approach considers the existing factory manufacturing culture and the lost events with respect to lean tools and techniques, to determine the lean tool gap the main waste of lean are identified with case company. Besides waste of lean absenteeism is one crucial event on factory productivity, included on study.

Finally, lean productivity improvement methods were propose. But in practical validation of lean tool 5why methods have been exercised to improve rework and defects , based on the average defect rate ,production rate, cycle time, production costs were improve by 40.91%,50.85%,13%,40.91%, respectively. Cellular manufacturing and other approaches have not been implemented, although the company has been left prepared for an implementation in the future.

Key words:-lean, productivity improvement, VSM, 5why method

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List of Acronyms

AGOA	African growth opportunity act
BPT	Basic pitch time
C&H	Candy and Helen
COMESA	Common Market for Eastern and Southern Africa
CT	Cycle time
ETIDI	Ethiopia textile industry development institute
FTA	Free trade agreement
GDP	Gross domestic product
IPDA	Industrial park development agency
KIP	Key performance indicator
KOAFEC	Korea Africa forum on economic cooperation
LT	Lead time
MOTI	Minister of trade and industry ³
OCT	Operator cycle time
PDCA	plan do check act
QC	Quality control
QL	Quality level
RT	Replenishment time
RQ	Reject quantity
SAM	Standard allowable minute
SD	sample defect
SPT	standard pitch time
SQC	statistical quality control
TPM	Total preventive maintenance
VSM	Value stream map
WE	worker efficiency
WIP	work in process
WPQ	worker produce quantity
WRM	waste relation matrix
WT	work station target

CHAPTER ONE

1. INTRODUCTION

1.1. BACK GROUND OF THE STUDY

Productivity improvement is one of the core strategies towards manufacturing excellence and it is also **necessary** to achieve good financial and operational performance. It enhances customer satisfaction, reduce time and cost to develop, produce and deliver products and service. Productivity has a positive and significant relationship to performance measurement for process utilization, process output, product costs, and work-in-process inventory levels and on-time delivery [1].

Improvement can be in the form of elimination, correction (repair) of ineffective processing, simplifying the process, optimizing the system, reducing variation, maximizing throughput, reducing cost, improving quality or responsiveness and reducing set-up time [1].

In order to achieve the company objectives, the industrial engineering tools and manufacturing philosophy helps to improve productivity due to their wide application area. Because of this, many companies are striving to practice lean manufacturing, which is a difficult process. Productivity improvement is not a job for specialist only; it should be a part of every job in the organization. It requires the optimal use of all resources like manpower, machinery, money and methods [2].

Besides lean, Work study techniques is helps to raise the efficiency utilization of the factor of production that have been used for all manufacturing and service sectors as a scientific approach, That aims to examining the way an activity is being carried out, simplifying or modifying the method of operation to reduce unnecessary or excess work, or the wasteful use of resources and setting up a time standard for performing the activity [3].

To solve the efficient improvement in productivity of garment factory by the help of Lean Manufacturing Principles & Tools helps to observe wide application area on productivity improvement. Since, Lean manufacturing tools is an influential & most effective methodologies for eliminating wastes (MUDA), controlling quality, and improving overall performance of any machine, system or process in any industry with the complete assurance of large annual profit margins.

1.2. Statement of the Problem

In Ethiopia the first industrialized garment industry dates back to the 1960s, with the establishment of Addis garments. Akaki garment was founded in 1963 followed by the Adey Ababa yarn Share Company, Gulele garment and Nazereth garment factory. These garment factories had domination on Ethiopia's garment sub-sector, where in the last few tenth years a number of private garment industries have been established [4]. Now a days the government gives great emphasis over garment sectors, so that in order to achieve the GDP plan one focus area is developing apparel and garment industrial park to attract foreign company. The Industrial Parks Development Corporation of Ethiopia (IPDCE) has mandate to develop and operate a wide range of industrial parks. It serves as Industrial Park land bank, develops IP and hands over to private Industrial Park developers (leases or sub-leases land sells or rents shades). IPDCE will develop 100,000 ha of land between 2016 and 2025 -i.e. 10,000 Ha annually- for a total factory floor area of 10 million m² (1 million m² annually) [5].

From developed IP, Bole Lemi is active and owned by foreign investors that has 143,000 square meter area from 17 shed, it also take an investment of 31,245,000.00 dollar capital with estimated number of employee about 5487 by Korea Africa economic cooperation [5]. Due to this huge country wide project, it needs primary focus in order to maintain the country industrial sector Activity and economical values for country local and foreign market. To analyze the production improvement, different garments have different efficiency by different influencing factor. Previous literature shows the main problem on garment productivity sectors are: -

1. Ethiopian textile and garment firms are not in a position to compete in the international markets due to the problems such as low productivity, limited quality awareness, limited capability of own design & development, ineffective and inefficient management structures, limitations of skills training, and inefficient systems [6].
2. Currently, in Ethiopia from ETIDI data there are 115 medium and large sized textile and garment firms that employ roughly more than 28,000 workers. With exports of about 65.117 million USD, that is comparably small amounts of foreign direct investment, it shows Ethiopia is not really present yet on the global map of textiles, Ministry of trade and industry – MOTI & ECBP [6] .

According to ETIDI export, plan and performance data shows 76.5%, 66.9%, 31.5%, 26%, and 53.62% are the actual achievement from 2004 to 2008 E.C. respectively. (See graph below)

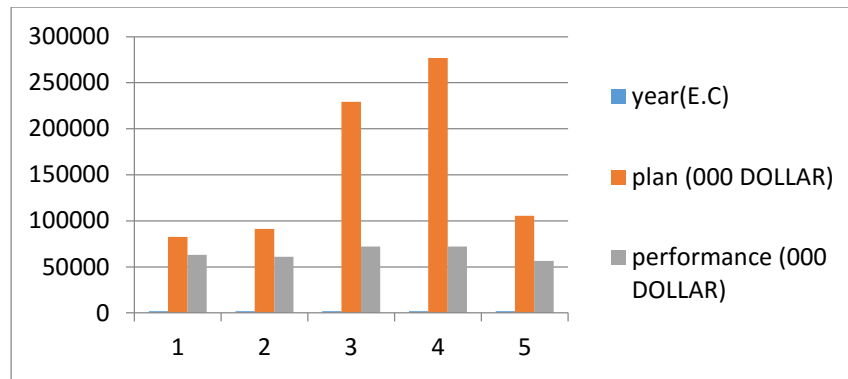


FIGURE 01: ANNUAL GARMENT EXPORT AMOUNT PER ANNUM

The sector has well defined market potential with the availability of the international good will to avail market privilege through free trade agreement (FTA), like Africa growth and opportunity act (AGOA) to US market common market to eastern and southern Africa (COMESA) on Africa market [7]. The country free trade agreement in AGOA utilization rates, 2013 report show Utilization rate of Ethiopia is 16.4% .based on this negative impact shows underutilized mill capacity; onerous customs procedures [8] .

3. The Garment industries in developing countries are more focused on sourcing of raw material and minimizing delivery cost than labor productivity because of the availability of cheap labor. Due to this, labor productivity is lower in developing countries than in the developed ones [9].

For instance looking labor productivity in garment sub-sector, one operator produces 5 polo-shirts per shift but the international benchmark is 20 to 24 polo-shirts per operator per shift [6] .

4. According to ETIDI narration the Ethiopia garment sector productivity on “T” shirt production is 40 pieces per operator per shift where as foreign bench mark productivity is 86 pieces per operator per shift.
5. According to [10] the efficiency of Ethiopia factories is as slow as 40 to 45% in production both textile and garment. The problem is due to under developer process and lack of education among of manpower, as compared to other countries production in Ethiopia takes about 40 to 60 days longer [10].
6. From survey on case company history shows among Bole lemi Industrial Park site industry, it is the first company that transfers privacy, with less production efficiency. The company history shows with three year experience, 11 million birr initial capital 32million birr negative balance was observed.

In general the study focuses to determine the extent to which the C&H garment productivity improvement hindering factors and tools to improve the productivity in the company, Then finally to propose scenarios how the case company can practice production improvement tools especially lean to get productive advantages in domestic and international market.

Following the problem justification, this research is therefore expected to answer the following questions:

1. What does the current status of C&H garment industry productivity?
2. What are the challenges of the productivity on C&H garment industry?
3. How does the factory will proceed to exercise efficient and effective production System?
4. What are the final recommendable approaches to improve productivity?

In short, this research seeks to identify which key issues must be addressed to successfully and continuously manage or eliminate non-value adding activities and manufacturing variables.

1.3. Objectives of the study

1.3.1. General Objectives

The general objective of the study is to investigate wastes that have a negative impact on productivity improvement of C&H garment industry.

1.3.2. Specific Objectives

The specific objectives of the study are:

- ✓ To identify types of waste that affect production efficiency and describe current status of production trend in C&H garment company.
- ✓ To develop systems to improve negative impact on productivity of C&H garment factory.

1.4. Significance of the study

The study will help to investigate hindering factors which affect case company productivity and to evaluate current status on productivity, and what will be recommended in future from lean perspective.

The research have benefit in overcoming the productivity problems so that the case company can be competitive in the national and global market. It is hopefully believed that similar garment industries implement the production improvement techniques and tools have a remarkable improvement, any related sectors can also use important concepts out of this research output asserts.

1.5. Scope of the study

The research will shows how the case industry production efficiency improve in a competitive status and can contribute a better production stand.

The study was carried out in Addis Ababa city bole sub city C&H garment factory that provides applicable and tangible productivity measurement and improvement techniques and tools, so that the overall activities of the selected company will share research result application commonly.

1.6. Limitation of the study

The research is limited to single case companies, and the study was undertaken in view of garment plant in C&H garment. The final research is not support by develop models.

1.7. Organization of the Thesis

The thesis is organized into seven chapters. The **first chapter** begins with an introduction to the thesis. **Chapter two** presents the related literatures review in the area of lean manufacturing, work study system, waste types, particular emphasis on lean tools application on productivity improvement, finally presents a summary of literatures reviewed and identified literature gap. The **third chapter** describes the research design and methodologies used in the research for data collection, analysis and result presentation. **Chapter four** describes the company status history and product types **the fifth chapter** discusses the data collected from the respondents, interpretations of analysis results and presentation of best alternative manufacturing system. **Sixth chapter** presents the implementation framework for the selected alternative. **Seventh chapter** the last and provides the conclusions, recommendations and future research works.

CHAPTER TWO

2. LITERATURE REVIEW

2.1. INTRODUCTION

Productivity usually deviates from production. Production concerns with an increment in output over a given span of time; productivity is concern with the ratio of output to an input. Putting in another way, improving productivity has to do with how effectively people combine different resources to manufacture parts and services that others dream to purchase. With the correct choices, improved production, higher values and elevated incomes can be accomplished for every hour worked [11] .

Mathematically Productivity may be defined as follows: [12]

$$\text{Productivity} = \frac{\text{Output}}{\text{Input}} \text{ ----- eqn. 1}$$

2.1.1. TYPES OF PRODUCTIVITY

Most of a time productivity type is bounded on material, machinery, and labour since other factors help to promote main productivity factors output.

A mathematical expression narrates the productivity is a total effort of worker machine, raw material productivity according to [13]

$$\text{oprator productivity} = \frac{\text{volume of out put}}{\text{Direct labor input (volume)}} \text{ -----eqn.2}$$

$$\text{productive efficiency of operator} = \frac{\text{SAM * unit produced per operator}}{\text{inputs in minutes per operator}} \text{ -- --eqn. 3}$$

$$\text{machine productivity} = \frac{\text{volume of out put}}{\text{machine input (volume)}} \text{ ----eqn. 4}$$

Another mathematical expression narrates the productivity is a total effort of worker machine, raw material productivity according to [13]

$$\text{oprator productivity} = \frac{\text{volume of out}}{\text{Direct labor input (volume)}} \text{ -----eqn.5}$$

$$\text{productive efficiency of operator} = \frac{\text{SAM * unit produced per operator}}{\text{inputs in minutes per operator}} \text{ -- --eqn. 6}$$

$$\text{material productivity} = \frac{\text{volume of out put}}{\text{input (volume)}} \text{ -----eqn.7}$$

2.1.2. HOW COMPANY PRODUCTIVITY IS MEASURED?

Productivity measures can be classified as single factor productivity measures (relating a measure of output to a single measure of input) or multifactor productivity measures (relating a measure of output to a bundle of inputs). Single productivity measures can also be defined over intermediate inputs and labour-capital. Multi factor productivity can, in principle, be evaluated on the basis of gross output. However, in the interest of simplicity, Table 1 was restricted to the most frequently used productivity measures. These are measures of labour and capital productivity, and multifactor productivity measures (MFP), either in the form of capital-labour MFP, based on a value-added concept of output, or in the form of capital-labour-energy-materials MFP (KLEMS), based on a concept of gross output.

Among those measures, value-added based labour productivity is the single most frequently computed productivity statistic, followed by capital-labour MFP and KLEMS MFP.

Table-1 Productivity Measure

Type of output measure	Type of input measure			
	Labour	Capital	Capital and labour	Capital, labour and intermediate inputs (energy, materials, services)
Gross output	Labour productivity (based on gross output)	Capital productivity (based on gross output)	Capital-labour MFP (based on gross output)	KLEMS multifactor productivity
Value added	Labour productivity (based on value added)	Capital productivity (based on value added)	Capital-labour MFP (based on value added)	
	Single factor productivity measures		Multifactor productivity (MFP) measures	

Source:

Generally, productivity should be considered as a comprehensive measure of how the Organizations satisfy the objective, efficiency and effectiveness.

2.1.3. PRODUCTIVITY IMPROVEMENT

The Productivity improvement is basically to enhance or escalate up the above mathematical values, based on this the productivity improvement is a core strategy towards manufacturing

excellence and it also necessary to achieve good financial and operational performance. It enhances customer satisfaction and reduce time and cost to develop, produce and deliver products.

In order to Attain Productivity improvement in garment the improvement should use a logical productivity improvement tools like lean best methods ,since they have wide application in productivity improvement area.the initial question is why need to select lean method from other improvement ? It is because of

1. Philosophy

The Lean Manufacturing philosophy centers on the customer. It could even be extended to be more broadly about people, from the customer to the lowest employee. This philosophy is intended to infuse the entire organization, focusing all activities to creating value for the customer.

2. Management

Lean Manufacturing has implications for management ranging from strategy to employee relations. Management must transform itself from playing a command and control role to playing a guidance and coaching role. This requires an empowerment of the employees that fosters teamwork, responsibility and ownership of processes and work man ship. Once the power is divested to the workforce, management may take on a more strategic role and focus on long-term goals.

3. Tools and Techniques

The tools and techniques used in implementing a Lean philosophy should be emphasizes the incorporation of philosophy and re-jigged management role are equally important to the successful implementation. The tools include the Just-In-Time system of input delivery and output delivery, with no wasteful accumulation of inventories. The other pillar of the Lean philosophy is automation. Automation builds a system of defect detection that stops production immediately if defects are detected. It is a system of automation with human guidance. Other tools support these pillars, but these are the primary supports of the Lean Manufacturing philosophy for primary choice.

Lean have more suitable than traditional manufacturing Literature sets a lean organization can make twice as much product with twice the quality and half the time and space, at half the cost, with a fraction of the normal work-in-process inventory. Lean management is about operating

the most efficient and effective organization possible, with least cost and zero waste [14].the other benefits of lean are summarize in table below.

TABLE 2: PRODUCTIVITY ELEMENT AND LEAN BENEFITS [15]

ELEMENT	BENEFIT
capacity	10 to 20% gains in capacity by optimizing bottlenecks
Inventory	Reduction of 30 to 40% in inventory
Cycle time	Throughput time reduced by 50 to 75%
Lead time	Reduction of 50% in order fulfillment
Product development time	Reduction of 35 to 50% in development time
Space	35 to 50% in space reduction
First-pass yield	5 to 15% increase in first-pass yields
service	Delivery performance of 99%

2.2. LEAN SYSTEM

Lean is a term to describe a system that produces what the customer wants, when they want it, with minimum waste - it is based on the Toyota production system. Lean thinking focuses on value-added lean and consists of best practices, tools and techniques throughout industry with the aims of reducing waste and maximizing the flow and efficiency of the overall system to achieve the ultimate customer satisfaction. This manufacturing philosophy shortens the time between the customer order and the product build/shipment by eliminating sources of waste. Another way of looking at lean is that it aims to achieve the same output with less input- less time, less space, less human effort, less machinery, less material, less costs [16].

Based on application, Lean manufacturing techniques there are five principles to guide management action towards success:

1. Value: The foundation for the value stream that defines what the customer is willing to pay for. If a company doesn't create value to its customers, it is hard to imagine any long-term prosperity. It is the level of effect that people personally expect from products and services, represented through lifestyle impact, enabling features, and ergonomics, which together result in a useful, usable, and desirable product.

2. The Value Stream: The mapping and identifying of all the specific actions required to eliminate the non-value added activities from design concept to customer usage.

3. Flow: The elimination of all process stoppages to make the value stream “flow” without interruptions.

4. Pull: The ability to streamline products and processes from concept through customer usage.

5. Perfection: The ability to advocate doing things right the first time through the application of continuous improvement efforts.

The lean tools are vast in scope & application area in order to make the research target full in garment sector the tendency to use lean tools depend on the final analysis, but the lean production system is geared by lean tools and techniques.

2.2.1. lean tools and techniques

Lean tools have not been derived or proposed in one single day. They have been derived from the people throughout the history. As they are why very complex & interdependent on each other and one can find similarities in one another. Currently in practice, there are approximately 25 Lean Tools, out of which, according to [11] Literature these five are considered to be the most critical effect of all, these tools can govern the garment productivity because it contains critical general concepts.

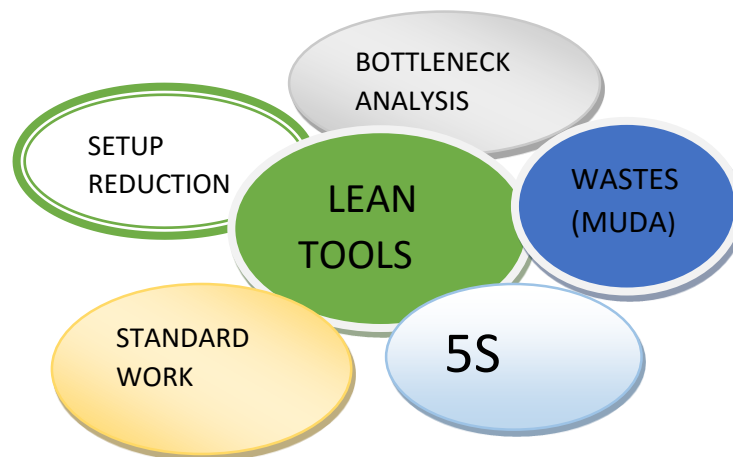


FIGURE 2: CRITICAL LEAN TOOLS EFFECTS [11]

1. Bottleneck Analysis

A garment process starts from cutting up to final product shipment causes to delay, interrupt on a point of concourse in a machine or system that arise when work load gathers at a point in the system more hastily than that specific point can hope to maintain them. The intricacies fetched about by the bottleneck often make a queue and longer overall cycle time. By definition, a bottleneck is a phenomenon where the competency of a complete system or line was restricted or limited by a single or limit number of components or resources & analysis of such event is called as Bottleneck Analysis.

Hence, Bottleneck Analysis is nothing but the identification of which part/machine or the manufacturing process/line limits the overall output and focuses on improvement the performance of that part/machine of the process/line. Bottleneck Analysis was usually done along with the Time Study Method. The system on which the analysis is required to be done was first selected. Then in the form of 'Daily Analysis', 'Minute to Minute Analysis; or 'Macro Second Study Analysis' the entire process is carry out along with the guidance of Time Study Methods [11].

2. Type of waste (muda)

Waste is anything that doesn't have contribution to transforming parts to the customer's need. The aim of Lean Manufacturing is to incorporate less human effort, less inventory, less time to develop products, and less space to become highly responsive to customer demand while producing top quality products in the most efficient and economical manner possible [17]. Typically the types of waste considered in lean manufacturing system includes Seven main types It can be identified in processes : [18]



FIGURE 3: SEVEN WASTE TYPES

I. Over production

Over production is producing more than essential by the subsequent process. Many numbers of production managers and supervisors assumes that a garment waste is caused by quality issues but Surplus garment manufacturing items possibly will be sold with cheap prices at the fiscal year end of the industry to match the finances for the subsequent year's inventory. In each production line, rejections of items occur in garment industry. The cost of overproduction for firms may be different dimension. Hence the management always fixes the production goal more than the buyer's requirement [19].

II. Waiting

Waste of waiting is directly relevant to flow and it is probably the most important waste. It occurs when time is not being used effectively. In a factory, this type of waste occurs when goods are not moving and it affects both the goods and workers. Waiting is directly relevant to lead time which contributes to competitiveness and customer satisfaction [20].

III. Excess Motion

Any unnecessary motion that does not add value to the product is waste [18]. Unwanted motion of worker in garment firms will result in time lag, waste of human effort and increased cost of the finished garments. Excessive motions in the manufacturing environment will cause delays of manufacturing and lot of troubles. Unnecessary motions mainly for undocumented work method and poor work flow. The mainly observable difficult effect in garment industries is the reducing the operational efficiency because of time loses in lifting, moving from one place to another place in garment, identifying and retrieving. Inconvenient manufacturing area for position of items of garments inputs also leads to a waste of energy time and labor force while arranging and identifying. If operator has to bend, stretch, pick up and move to see better. Unnecessary motions refer to the importance of ergonomics to reduce defects and quality of garments. No ergonomics principle is applied in all sections of garment; moreover, the employee does not follow 5S concepts, because of every operator involved in unneeded motion. Sometimes employees leave his/her work place without any reason which is not desirable for any type of garment process [19].

IV. Transportation

Moving material does not enhance the value of the product to the customer [18]. Transportation is defined as dispatch to and from outside the firm. Transportation of completed garment items normally made by an appropriate firm process in most of the garment industries facing major impact of lean. Every interval in garment production that causes waiting time has the possible to allow work in progress to accumulate. Lean demands that the items be shipped directly from the vendor to the particular location where it will be used. [19].

V. Inventories

This is the classic waste. All inventories are waste unless the inventory translates directly in to sales. It makes no difference whether the inventory is raw materials, work in process (WIP) or finished goods. The level of equipment support should be given attention in lean manufacturing because some manufacturing processes rely heavily on their equipment to produce products. [21]. More research articles suggest that 60% of wastes occur in garments industry due to inventory. This inventory reduction not only save cost but also tolerates the minimum manufacturing lead time. The high interests of labors for bonus amount in increased garment manufacturing leads to elevated inventory level. Poor record keeping, miscommunication with suppliers and clients and irregular management decisions will result in elevated inventory levels. [19].

VI. Over-processing

Extra processing not essential to value-added from the customer point of view is waste [18]. Many research articles point out to the over processing is more important to reduce the wastages in firms. As a result, it is important to focus at all operations in garment firms as potential waste. Incorrect processing results from the wrong set of tools, low standard machines, lack of communications and unnecessary information regarding product changes without process changes [19]. Engineers who make specifications that are

VII. Producing defective products

Defective products impede material flow and lead to wasteful handling, time, and effort. These wastes appear in every manufacturing activity. The most important tasks of companies are to identify, manage, and minimize these wastes in order to become more competitive [18].

Modification, rejection of garments is the common scenario in all section of garments. Mostly defective materials in garments may add supplementary changes in design, quality and nature of work. Due to poor quality of materials and tools, in unnecessary process, human errors and design errors, defect occurs. Minimum number of production processes may attain good quality in each time. Defective items can cause both indirect and direct cost occurs in firms. The costs arise from defective items are problems to a garment manufacturing firms. The high requirement of manufacturing items and defective items can lead to less gain to firms. If the outcome is accepted quality, it may reach the client [19].

On the basis of these seven wastes and its thirty three types of cause about garments, framed from literature review [19] the following Table 2 is Clearly represents the dependability of Man, Machine and Material against various types of wastes framed by literature on lean experts of garments.

TABLE 3: PROFILE-WASTES MATRIX IN GARMENT FIRMS [18]

Types of garment wastes	Possible Causes	Defect source			
		Man	Machine	Material	Others
Over production	Unlevelled scheduling	√			
	Un balanced work load	√			
	Lengthy process step		√	√	
	Misuse of automation	√			
Transportation	Large batch size	√	√		√
	Poor plant layout	√			
	Large storage area				
	Poor understanding of the process flow for production	√			
	Longer lead times		√	√	
Defects	Seaming defects	√	√	√	
	Sewing Defects	√	√	√	

	Placement Defects	√		√	
	Fabric defects	√		√	√
	Embroidery defects		√		
Inventory	Unlevelled scheduling	√	√	√	
	Poor market forecast	√	√		
	Un balanced work load	√			√
	Unreliable shipment by suppliers	√			√
Over processing	Styles changes without process changes	√			
	Lack of information about process	√		√	
	Customer true requirement not properly defined	√			
	Redundant approvals	√			
	Over processing to accommodate expected down time		√		
waiting	Poor scheduling of production process	√	√		
	Time taken for signature approval from higher officials to take require decision	√			
	Improper arrangements of machines for process sequence	√			
	In adequate servicing of machines	√	√		
motion	Large items located on upper or lower shelf	√			
	A machine that unnecessary travelling distances	√			
	Finding necessary equipment and tools for concern production process	√			
	Unnecessary motion from work place to retrieve materials or utilize machines	√			
	Unplanned tools for work place	√			
	Lack of space in organization in manufacturing area for keeps the components	√			

3. Five “S”

First S: “*Seiri*” or Sort.

Anything that is not used or needs in the workplace gets in the way of the actual work being done there. An area should be set aside nearby to put these unnecessary items and the items in which there are uncertainties. Just about anything can be put into this holding area, including items that may or may not be used such as

- Machinery – sewing machines, cutting knife, ironing machine, etc.,
- Stock - Raw materials, parts, assemblies, etc.,
- Tools and Equipment – Trimmer, Screw driver, hammers, etc.,
- Facilities - Work tables, chairs, desks, etc.,
- Documents - Files, notices, awards, memos, folders, etc.,
- Stationery - Pencils, staplers, erasers, paper, etc.,
- Fittings - Nuts, bolts, wire, hooks, etc.,
- Locations - Rooms, bays, floors, shelves, etc., and
- Others-Catalogs, radios, magazines, books, etc. ([22]).

Second S: “*Seiton*” or Set in order.

The second step in a 5S launch is taking the stored items and putting them where best support function will provide. Workers should be motivated to place items at their point of use and improve the workplace’s visual management. One important advantage of Set in order is that

- Everything needed for the job is clearly visible.
- Arrange the work in such a manner that missteps can be easily identified and corrected

The practice of shadow boarding can be quickly identify when a piece of equipment is missing from a work station. There are several different strategies used to set in place or order, which can be used apart or together. The signboard is a strategy, which identifies what, where and how many items should be stored. There are three main types

- Location indicators, which show where items go,
- Item indicators, which show what specific items go in those places, and
- Amount indicators, which show how many of these items, belong in those places[23]

Third S: “Seiso” or Shine.

Seiso means to keep everything swept and clean. This is done with the objective of inspecting for problems and taking faster corrective actions. The implementation of Seiso is done in the following manner:

- Determine Shine targets (Storage space, Equipment or Empty Space)
- Determine Shine assignments (Divide job based on area of cleaning, Divide job based on time of cleaning)
- Determine Shine Methods (Choose the right tools, Shining time, How much to shine should be defined)
- Prepare tools (Keep tools near location of shine)
- Start to Shine (Clean thoroughly) [24]

Forth S: “Seiketsu” or Standardize.

The standardization is needed to make the first two pillars easier for the organization to maintain, and this is called habit reinforcement. So, many processes become more close to the real working habit. It will involve the responsibility assignment, the cleaning and ordering task recognition and the execution control. This S is also called Visual Control, even if sometimes this is considered a stand-alone tool [22] [23].

Fifth S: “Shitsuke” or Sustain.

In a company, generally, few people have the authority to set tasks on employees e.g. managers and section heads; but it is important as well to obtain the support from operators who lead worker groups. Finally, the discipline is the base that sustains all the other 4S, as it brings to good work habit maintaining [22].

By sustaining all of the 5s steps, many problems in the work place can be avoided including

- Unneeded items piling up as soon as the sorting process is completed.
- Tools being put in the wrong place after use.
- No one ever cleaning equipment or picking up after themselves.
- Items being left in walkways.
- Dark, dirty work environments which lower morale of employees, and
- Dirty machines which start to malfunction and/or produce defects [22].

4. VALUE STREAM MAPPING (VSM)

VSM is a world-famous graphical tool which helps to enlighten and analyses the work-flow in process starts from raw material delivering up to final customer product shipment and to find the value added and non-value-added activities contributing to the final product. Lean concepts and techniques are used collectively in VSM. Analyses of the current state of the value stream of a product are carried out. After this redesign, an improved future state of the value stream of the product is developed which is mainly focused on the reduction of wastes, the decrease in lead times, and improvement in the material-flow. Only one map is required to show the flow of both material and information, which are found to be important characteristics of VSM when comparison is made with other such types of technique. This analyses be in order to reduce non-value-added activities, which will contribute in reducing waiting time, queuing time, moving time, and other similar wastes. To construct VSM symbols have their own meaning to demonstrate the information & production process the Fig 4 below shows the value stream symbols uses to describe each process of manufacturing or assembly [25].

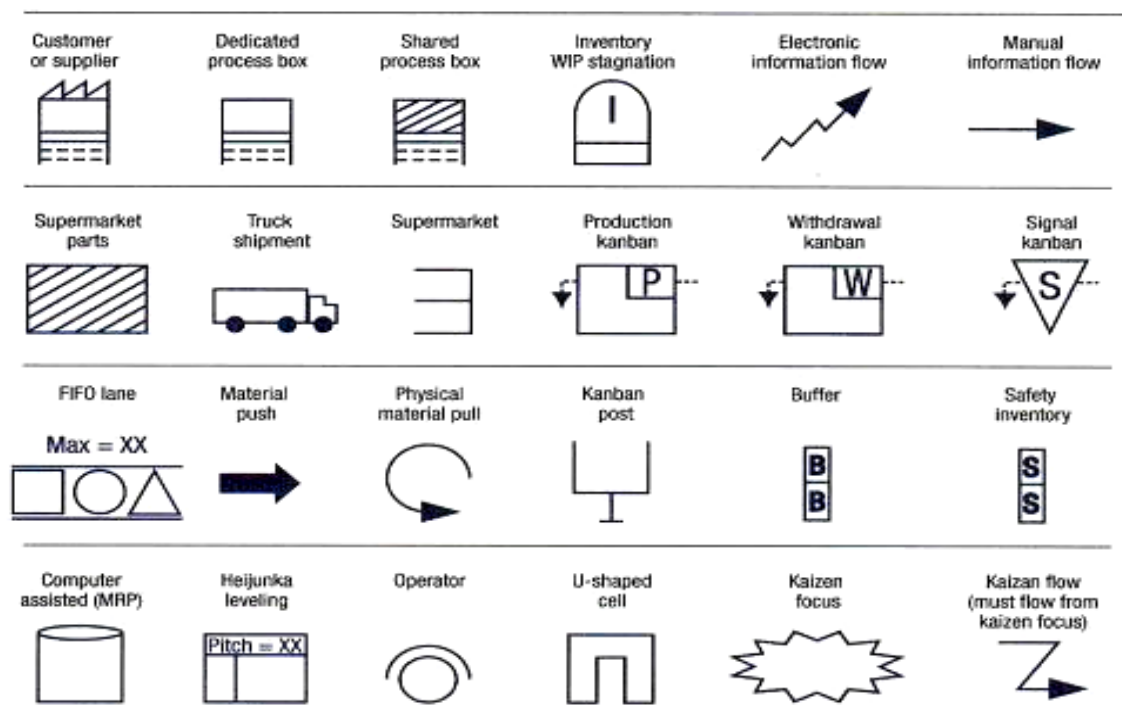


FIGURE 4: VALUESTREAM MAPPING SYMBOLS. [20]

Cycle time (CT)

It is defined as how frequently a finished product comes out from the production facility. Cycle time includes all types of delays take place while completing a job.

Value Add time (VAT):

Time of those work elements that actually transform the product in a way that the customer is willing to pay for.

Lead time (L/T):

The time it takes one piece to move all the way through a process or a value stream, from start to finish.

Changeover time (C/O):

The time that is required to switch from producing one product time to another.

Uptime (on demand machine time):

The period of time that an equipment or machine is up and running (in service and operating).

Available working time:

The time that the operators give into performing an activity, excluding the breaks and lunch times.

5. 5 why method

Five Why (5 Why) Analysis: Invented in the 1930's by Toyota Founder Kiichiro Toyota's father Saki chi and made popular in the 1970s by the Toyota Production System, the 5 Whys strategy involves looking at any problem and asking: "Why?" and "What caused this problem?". The idea is simple. By asking the question "Why" one can separate the symptoms from the causes of a problem. This is critical as symptoms often mask the causes of problems. As with effective incident classification, basing actions on symptoms is worst possible practice. Using the technique effectively will define the root cause of any nonconformance and subsequently lead to defining effective long term corrective actions [17].

6. Kanban

The Kanban system determines the production quantity in every process. It is known as the nervous system of Lean Production. Kanban is a Japanese word that means "instruction card". Kanban are manual pull devices that allow an efficient means to transfer parts from one department to another and automatically reorder products using minimum/maximum inventory levels. A Kanban is a signal, such as an empty container returned to the start of the assembly line, that signals the need for replenishment of materials to a user [26].

6.1. Kanban Characteristics:

Kanban is based on management inventory system called “reordering point method”. Kanban minimize waste by using “Level Production”. Level production depends on setup time reduction “Quick Changeover”. Kanban system serves as the production order for the Pull system. The order point is determined by the pacemaker based on the Takt time. Order Information travels Upstream from sales demand to assembly to Suppliers - The Pull system travels from Downstream to Upstream [27].

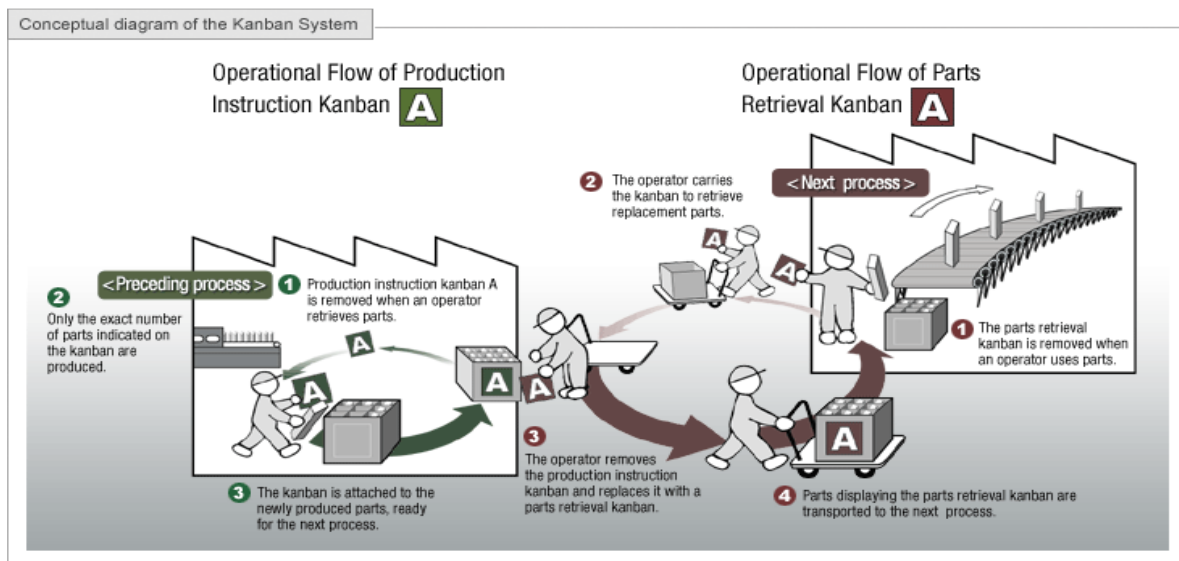


FIGURE 5: KANBAN CONCEPTUAL DIAGRAM [28]

Functions of Kanban: The Kanban system has several important functions:

1. A communication system
2. Pick Up and work order information
3. Elimination of overproduction waste
4. A tool for visual control
5. A tool for promoting improvement

All lean has their own distinct application area through which the target company should play the technical tools, in order to clarify the application area and lean tool difference the following table 3 address application area of lean tools.

TABLE 4: SUMMARY OF MAJOR LEAN TOOLS AND THEIR BENEFITS [23]

LEAN TOOL	MEANS	HELP TO MANUFACTURING INDUSTRIES
5S	Sort, Set in order, Shine, Standardize, Sustain	Eliminates waste that results from a weakly organized work area (e.g. wasting time for looking tools)
ANDON	Visual feedback system for immediate operation	Real time communication tools for immediate attention to problems
Bottleneck	Analysis Identifying the weakest link	Strengthening the weakest link.
HEIJUNKA (Level Scheduling)	Scheduling and sequencing production process.	Reduces lead time and inventory
HOSHIN KANRI	Goal alignment with tactics and action	Ensures the security towards the goal.
JIDOKA (Autonomation)	Design equipment for semi-automatic process.	Reducing labor cost with improving quality.
Just In Time	Pull production process.	Reducing inventory levels and space requirements
MUDA (WASTE)	Eliminating waste in manufacturing area and maintain inventory.	The elimination of waste is the primary focus of lean manufacturing
KAIZEN	A strategy where employees work together and slowly incremental improvements in the manufacturing process.	Joined the collective talents of a company to create main for continually eliminating waste from manufacturing processes.
KANBAN SYSTEM	Regulating the flow of goods both within the factory and with outside suppliers and customers	Eliminates waste from inventory and overproduction. Person cannot need physical verification.
OEE (over all equipment effectiveness)	Measuring productivity loss and quality performance and give its overall framework.	Give the idea of manufacturing process baseline which means that perfect production
POKA YOKE	Error detection process in manufacturing area with goal of zero defect process	Eliminate defects by preventing, correcting or drawing attention to human error.
Root cause analysis	Focuses on resolving the fundamental problem instead of applying quick fixes that only treat immediate symptoms of the problem	Helps to ensure that a problem which find is truly Eliminated by using root cause analysis.
Total productive maintenance (TPM)	This is approach to maintenance that focuses on proactive and preventative maintenance to maximize the operational time of equipment	In the right environment this can be very effective to improve productivity and reducing cycle times and eliminating defects.
PDCA (Plan, Do, Check, Act)	Step by step method for improvement	Applies a scientific approach to making improvements
KIP (key performance indicator)	Metrics designed to track and encourage progress towards critical goals of the organization	Are aligned with top-level strategic goals & effective at exposing and quantifying waste.
Single –minute exchange of dies	Reduce setup (changeover) time to less than 10 minutes.	Enables manufacturing in smaller lots, reduces inventory, customer responsiveness

SMART Goals	Goals that are: Specific, Measurable, Attainable, Relevant, and Time-Specific	Helps to ensure that goals are effective.
Standardized work	Documented procedures for manufacturing that easily capture for best practice. Documentation is easily changed.	Part is easily available so that less inventory is stored.
Value Stream Mapping	This tool is showing that current and future flow chart of processes and suggests that where and what have to improve.	Exposing wastage in processes.
Visual Factory	Improve communication by using visual indicator displays and controls.	Makes processes easily accessible and clear.

7. TAKT TIME

TAKT is German word for a pace or beat, often linked to conductor's baton. Takt time is A reference number that is used to help match the rate of production in a pacemaker Process to the rate of sales. This can be formulated as below [29]

$$\text{Takt time} = \frac{\text{Available working time pr shift}}{\text{customer order quantity per shift}} \quad \text{-----Eqn.8}$$

Takt time can be defined as the rate at which customers need products i.e. the products should be produced at least equal to takt time to meet the customer demand. Takt time works better when customer demand is steady and clearly known; but if the customer demand varies on the daily basis then it is difficult to calculate the takt time as well as balance the production facility according to varying takt time. So if the orders are varying every day the information of actual shipments (not orders) should be gathered for last few months or years and takt time for the particular product should be calculated. In this way, the production can be balanced to meet changing customer demand.

8. Cycle Time

Cycle time is defined as how frequently a finished product comes out of our production Facility [29]. Cycle time includes all types of delays occurred while completing a job. So cycle time can be calculated by the following formula.

$$\begin{aligned} \text{Total Cycle Time} = & \text{processing time} + \text{set up time} + \text{waiting time} + \text{moving time} \\ & + \text{Inspection time} + \text{rework time} + \text{other delays to complete the job} \text{----- Eqn.9} \end{aligned}$$

To meet customer demand or monitor productivity the cycle time and takt time should be balanced in parallel. The higher cycle time than takt time may result the late delivery and

customer dissatisfaction whereas shorter cycle time than takt time may cause the excess inventory or excess use of resource.

2.3. WORK STUDY SYSTEM

Work Study is the systematic methodology of carrying out different yet related activities such as to improve the efficient use of resources and to set up standards of performance & quality for the activities to be carried out. It is the analysis of a job for the sheer purpose of finding the subsequent method of doing it and also determining the required standard time to perform it by the selected or given method. Work Study generally is classified in two areas: Method study (Motion study) and Time study (Work measurement). Motion and time study is the systematic study of work systems` with the following purposes

- (1) Developing the preferred system and method-usually the one with the lowest cost;
- (2) Standardizing this system and method;
- (3) Determining the time required by a qualified and properly trained person working at normal pace to do a specific task or operation; and
- (4) Assisting in training the worker in the preferred method [30].

2.3.1. Method Study (Work Method Design)

Method study focuses to achieve the better method of doing work, and for this reason method study is sometimes called Work Method Design. The following steps depict the procedure for creating a method study.

1. Select (the work to be studied).
2. Record (all relevant information
3. Examine (the recorded information).
4. Develop (an improved way of doing things).
5. Install (the new method as standard practice)
6. Maintain (the new standard proactive) [11].

2.3.2. Time Study (Work Measurement)

Work measurement refers to the estimation of standard time for an activity that is the time specific for completing one finished garment product job by using the predicted method. Standard time can be evaluated through the time utilized by an average experienced skill full operator for the job with provisions for delays beyond the operator's control.

A work has to be measured for the following reasons:

- To identify and eliminate excess job routine
- To install standard times for performance measurement.
- To measure performance against [11].

2.4. WORK STUDY FOR LEAN MANUFACTURING

Lean manufacturing requires maps of the sequence of the process. This is done with the method study called process chart, which is capable of provide means for analyzing and improving the process which is imperative for lean manufacturing implementation. During a method study, jobs are divided into elements, which can be timed using stop watch or PTS (production time standard) such as MOST (mean operating standard time). Through the evaluation of the common work study tools such as Process Mapping and Multi Machine Chart, the first important element that contributes to the labor productivity determination is the operator's utilization or the time spent to perform a set of activities over a period of time. Operator's utilization consists of the operator's activity time, the number of time each activity is repeated (frequency) and the time-frame in which the whole process is repeated. [31].

In order to stress the roles Work Study in lean manufacturing, it is necessary to compare Work Study in mass production to the one in lean manufacturing

TABLE 5: COMPARISON OF WORK STUDY IN MASS PRODUCTION AND LEAN MANUFACTURING [28].

Components	Mass production	Lean manufacturing
FOCUS	Narrowly specialized work place, with worker trained to perform small set of simple operations; Work study analyzes objects and processes in a work place that is a part of a wider manufacturing process; Time used as a measure of fitness and for production planning and control;	Workplace, work cell, entire manufacturing process, supply chain, etc., analyzed in its entirety; Multi-skilled and flexible workers; Focus on obtaining improvements quickly; Time used mainly as a measure for savings obtained through method improvement;

APPROACH	Mutually conditioned phases, with often reversion to previous steps for check; Approval of each phase; Thorough analysis and coordination between different phases that require a lot of time;	Simple approach which is easy to learn and apply; Less time spent on thorough analysis and coordination; The aim is to come to a solution that is better than the existing one, that will be further advanced through continuous improvement; Improvement projects are carried out autonomously by team members; Improvement projects action oriented, often lasting only a few days;
ORGANIZATION	Managers make decisions, approve phases, and are responsible for implementation; Experts help managers with solving problems; Workers execute managers' decisions; Consultants are responsible for training experts and have counselling roles;	Managers create preconditions for work team to work on improvements; Experts serve as internal consultants; Workers are equal members of improvement teams who design, apply, and standardize improvement solutions, with the application of Work Study and Kaizen approach;
INSTRUMENT	Large number of instruments makes difficult to master them, choose between them and use them when and where appropriate; Both simple and more complex Work Study instruments at disposal;	Both Work Study and Kaizen instruments are used; Instruments divided into smaller groups in accordance to specific problems, which facilitates selection and implementation; Simple and more complex Work Study and Kaizen instruments at disposal;

Work Study method in lean manufacturing is simplified, so workers can easily master it and apply it very quickly. Method study is at the forefront in lean manufacturing, while time is used for measuring the fitness of the method, so it can be said that both method study and time measurement are both used in lean manufacturing. Workers analyze the existing method and design new one, while industrial engineers serve as internal consultants and help and inspire workers to create changes [32].

2.5. SUMMARY OF LITERATURE REVIEW AND RESEARCH GAP

2.5.1. SUMMARY OF REVIEW PAPERS

Using key words: productivity improvement, garment factory productivity lean manufacturing system, lean tools, work study & lean system, different databases has been searched for accessing journal articles relevant to the research. The inclusive databases were Emerald, Google scholar, Elsevier, Springer, science-direct, IJERT, Academic journals, Taylor & Francis, Research gate, etc. The major sections of literature review were: lean system, work Study system literature review parts are outlined and structured in a manner that the reader can easily understand and research gaps can be identified. The types of journal papers reviewed are summarized way but according to the degree of relation and proximity thirty-one journal are detail revised by table form Appendix B. From revised journal more dominant lean tools are VSM, work study, JIT and kaizen, other analysis tools are pareto graph & fish bone diagrams are common in most journals uses for their paper purpose.

In general, forty productivity improvement journal in lean method was revised their tools for paper purpose the result show that: - work study, vsm, line balance, cellular manufacturing, kanban, work standard, 5s, JIT were most crucial issue on paper uses for productivity improvement but other tools like pareto Analysis, cause and effect diagram, 5why, bar graph, and pie charts were used to elaborate the journals.

- Almost all of the reviewed literatures applied by selecting hybrid by integrating lean methods with work study,.
- From reviewed literature only two papers particularly focus on workers but most paper tendency is on productivity by creating favorable work condition by lean tools especially waste identification and improvement procedure.
- Most literature uses value stream map (VSM) as a main lean tool with in productivity improvement in order to identify value add and non value add activity and to demonstrate peacemakers.
- From observed literature work study method is an influential methods to improve productivity in corporate with lean tools by time study and method study

methods,because of in analysis lean the takt and cycle times are measured through stop watch time study.

2.5.2. LITRATURE GAP

An extensive literature review was conducted to support the thesis with different perspectives This study has examined twenty two papers in detail directly related to the subject matter under examination. After reviewing these selected papers, the following literature gaps are identified:-

- Most studies paper focuses on the selection of best alternative to eradicate the wastes on manufacturing systems based on the lean tools. But most of the waste is generated by human factor as reviewed on literature so the researches puts forward the ways how to focus on productivity improvement and the eighth lean concept.
- In most research theoretical justifications are set as a final destination of paper but in most research not validate practically.

Based on the literature summary and survey; the problems area through which the research paper concerns are , on employee motive on productivity, impact of wastes, so that the ways of productivity improvement main target will be: -

1. These concerns on worker's motive on productivity, absenteeism, turnover, are analyses and training type.
2. These concerns on improvement of work area by reducing lead time, eliminate bottle neck, and waste reduction through lean tools.

CHAPTER THREE

3. RESEARCH DESIGN AND METHODOLOGY

3.1. Research Design

This research in terms of purpose is considered as an applied research. Applied research aims at finding a solution for an immediate problem facing a society or industrial/business organization and its findings could have scientific use. The research is mixed (qualitative & quantitative) in its approach where subjective qualitative judgment of group decision makers will be collected through questionnaire and interview, the quantitative data is gathered by on work area observation method with stop watch time records. For the successful achievement of the general objectives and specific objectives of the research, the following research methodology has been used. Therefore, the overall research design of the thesis includes: literature review, data collection, analysis, result presentation and interpretation, implementations & improvement frame (ways forward), conclusion and recommendation, and the future research direction.

The research has been started with the preliminary surveys to identify research area and to select the topic which was mainly accomplished through the factory visit and literature survey on lean productivity improvement on garment factory.

3.2. Methodology

3.2.1. Literature Review

The research started with an extensive literature review to understand the subject matter in depth and to identify the research gap where this research result will contribute into the field. Basically the literature review main subject areas: Lean tool application on garment productivity improvement, work study method integration in lean application, and worker culture in garment industry. Different literatures conducted on lean application on productivity improvement in garment manufacturing are reviewed to understand how the problem has been solved in other countries by different researchers. The general conceptual procedure to practice research is shown below fig 6.

The procedures for this study have been chosen to meet each of the operation objectives. To have a first-hand knowledge of the production flow and to be familiar with the activities being performed at the floor shop, the researcher went through the facility and identified each operation process involved from raw materials to finished goods, identified all the places where

inventory is stored between the processes, and observed how the material flow from one operation to another.

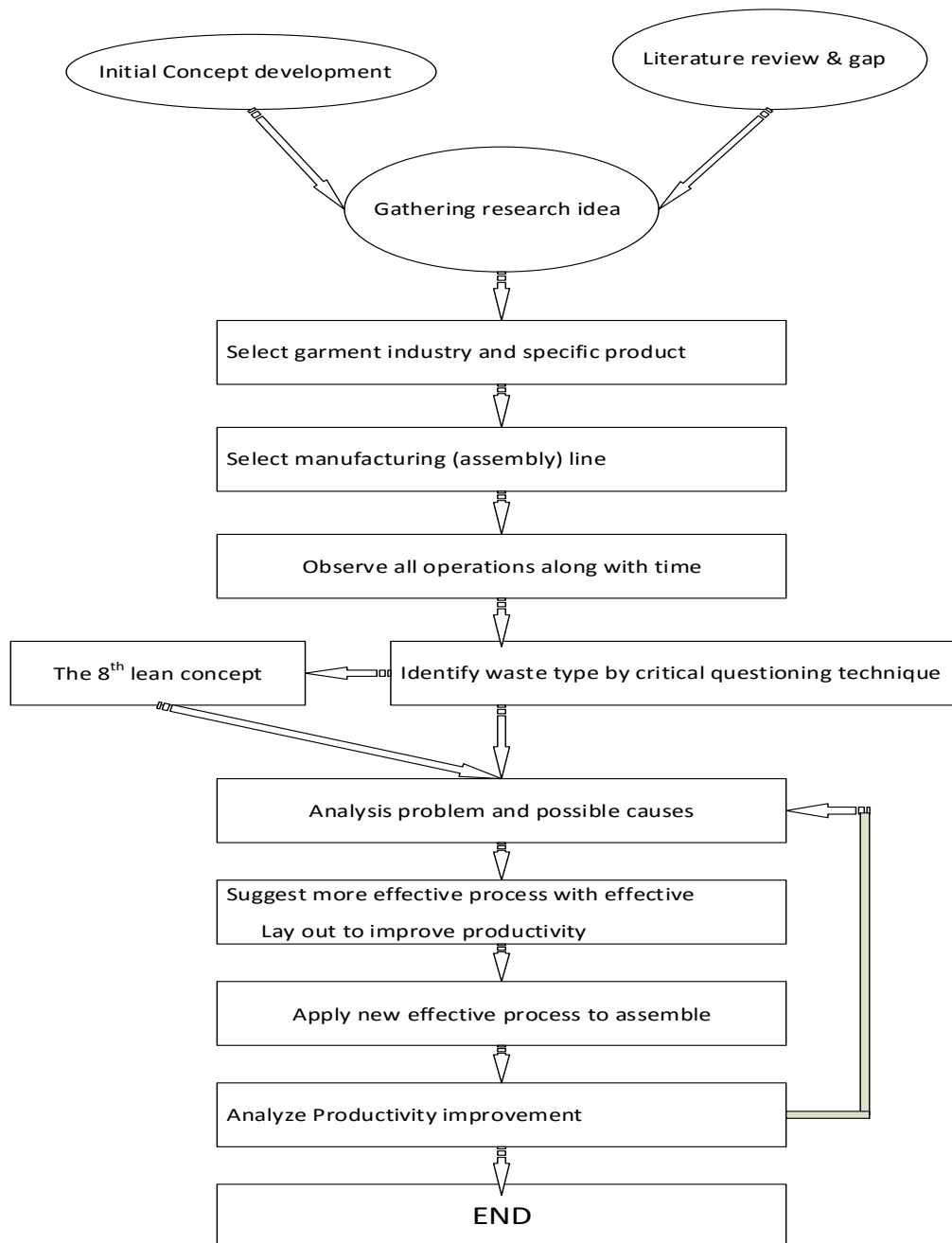


FIGURE 6: RESEARCH CONCEPTUAL MODEL

3.2.2. Data Collection and Source of Data

Combinations of qualitative and quantitative methods have been used to achieve the objective of this thesis. The secondary and data are collected from different sources. The secondary data has been collected are mainly from journal article, books, conference and online data bases. In the same way, primary data relevant to the research in achieving its objectives are collected

through semi-structured questionnaire based survey, face-to-face interview with respondents and observation on work place from case company.

The survey questionnaires are revised by the advisors and peer reviewed with class mates before they are distributed to the respondents. Therefore the questionnaires are distributed to respondent at the presence of the researcher and necessary guidance is provided to make clear the objectives of the questionnaires.

3.2.3. Data Analysis Methods and Tools

To analyze the data collected through questionnaire, and on production floor observation will developed and applied to aid and facilitate the decision on productivity improvement is used to determine the degree of influence each selection criteria/sub-criteria could have impact on lean approach analysis.

Finally, the collected data will have summarized through different Arithmetic, statistical, Graphical and narrative paragraph expression, the methodological framework of the proposed thesis procedure has been developed, as it can be seen on Figure 7. To facilitate the calculations and analysis of large data and tables, Microsoft Excel is used as tool, for graphical analysis micro soft Visio professional. The results of the calculations are presented in the table and charts and interpretations of the result were done verbally.

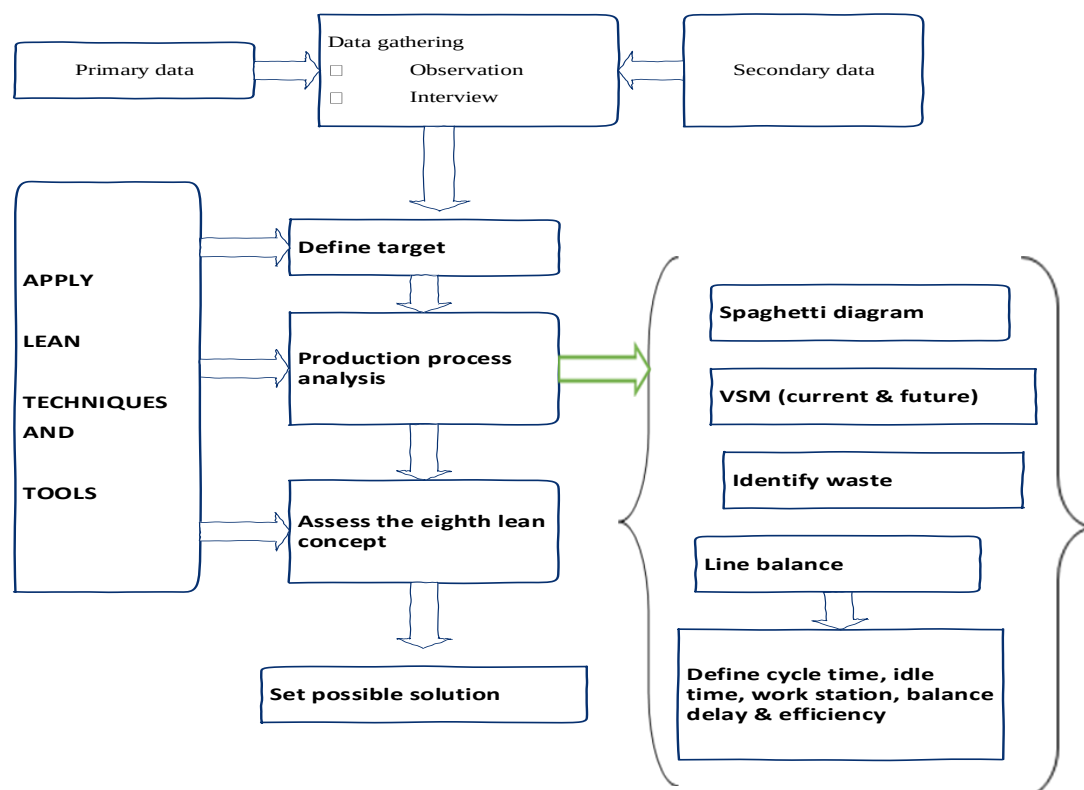


FIGURE 7: RESEARCH METHODOLOGY

3.3. Procedure for lean method productivity improvement

3.3.1. STEPWISE PROCEDURES.

Applying LEAN philosophy on productivity improvement by work study methods enables researchers to analyze the step wise critical productivity improvement hindering factor identification and analysis process is presented as below:

Step-1: Define line target(LT)

Line productivity is based on the number of line workers and product cycle time. To increase workers' productivity, the Factory sets a target for each production line, and the line supervisor is responsible for achieving that target. The line target represents the number of units required during a single shift hour per day. it can be calculated as below:

$$\text{Line target (LT)} = \frac{LW \times (\text{hours per shift}) \times 60}{PCT} \quad \text{-----Eqn.10}$$

LW= the number of line workers

PCT = the product's cycle time in minutes

Step 2: Work station target (WT) & worker efficiency (WE)

The work station target for each operation is calculated based on worker numbers at each work station. The work station target is calculated using Equation.

$$\text{Work station target (WT)} = \frac{OW \times (\text{hour per hift}) \times 60}{OCT} \quad \text{-----Eqn.11}$$

To measure worker's efficiency, worker produced quantity is used as expressed by Eq.

$$\text{Worker efficiency (WE)} = (\text{WPQ} \times 100\% / T) \quad \text{-----Eqn.12}$$

where OW is the number of worker(s) in each work station of the same operation, OCT is the operation's cycle time in minutes, WPQ is the worker produced quantity at his/her operation, T is the individual worker target production at his/her operation, and 60 denotes minutes /hour.

Step 3: Define current-state VSM

All data required for construction of the current-state VSM were collected while walking the line processes, starting at customer orders and terminating with shipping the finished product

to the customer. Overall data collected included ordering quantities and frequency, materials and information flow, inventory level, and shipping time. For each work station, specific data were collected, such as operation cycle time, worker numbers, daily available time, and inventory levels. Data were collected using direct observation and information from the production manager, line supervisor, quality control, and workers.

Step 4: Process Waste Analyses in the Current-State VSM

Plant observations combined with detailed analyses of the current-state VSM of the line revealed types of waste: During the study period the different wastes were observed to analyze their characteristics and nature and then to quantify their impact using lean measures.

Defects,

The Factory, defects were evaluated using two daily measures: quality level percentage (QL %) and rejection percentage (R %). Equations below describe both measures, selectively. In addition, quality level percentage is used at the factory to inform management as to overall quality level at the company.

$$\text{Quality level percent (QL\%)} = \frac{\sum_{i=1}^n SD}{\sum_{i=1}^n S} \times 100\% \quad \text{-----Eqn.13}$$

$$\text{Rejection percent (R\%)} = \frac{\sum_{i=1}^n RQ}{\sum_{i=1}^n LQ} \times 100\% \quad \text{-----Eqn.14}$$

where, SD is sample defective pieces, n is the number of samples per day, S is the sample size, RQ is the size of the rejected lots at packaging quality inspection, and LQ is the size of inspected lots at packaging quality inspection station.

Inventory,

Each inventory quantity between work stations is converted into an NVA time by dividing the inventory quantity by the product daily demand. This NVA time then can be converted into cost using equation below.

$$\text{Inventory cost} = \frac{IQ \times \text{hours per shift} \times Ch}{D} \quad \text{-----Eqn.15}$$

D

Where IQ is the inventory quantity, and D is the daily demand.

Overproduction,

Overproduction quantities can be calculated by subtracting the work station's daily target, calculated from Equation below, from the work station's actual daily production. If the result of subtraction is positive, overproduction is found.

$$\text{Over production cost} = \frac{Q - WT}{60} \times OCT \times Ch \text{ -----Eqn.16}$$

Where Q is the actual work station production, WT is the work station target based on Equation OCT is the OCT in each work station, and 60 denotes minutes per hour.

Transportation,

A formula was developed to count movement numbers in the line. This can be estimated if the number of workers in each two consecutive work stations is known. The required formula used to estimate movement numbers in the sewing line is expressed in equation below.

$$\text{Line movement number (LMN)} = \sum_{i=1}^N N_i - 1 \times N_i \text{ -----Eqn.17}$$

Where N is the number of work stations in the line, $N_i - 1$ is the preceding work station, and N_i is the following work station to $N_i - 1$.

Waiting time.

During the study period, buffers were used to absorb fluctuations in production flow throughout the process line. To quantify this waste, the produced quantity at each work station was recorded and compared to the work station target. reasons for waiting time in the line emerged, such as slow workers at previous work stations, machine failures, and inefficient distribution of workers at various stations. Waiting time cost was computed for each work station using equation below: -

$$\text{Waiting time cost (WTC)} = \sum_{i=1}^{12} (WPQ - WT) \times OCT \times Ch / 60 \text{ -----Eqn.18}$$

Where WPQ is the worker's produced quantity, WT is the work station target, OCT is the OCT in each work station, and 60 denotes minutes per hour.

Over process

Occurs any time more work is put on a piece than is required by the customer. This also includes using components that are more precise, complex, higher quality or expensive than absolutely required

Waste of Motion

The Waste of Motion is usually created in work cells which have not been planned correctly. Inadequate planning lead to unnecessary motion when tool or any other object which is not placed correctly inside work cell.

STEP 6: Assess the eighth lean concept

Absenteeism in garment industry is alarming un control able situation, besides this worker turnover is other challenge these two factors have an impact on company productivity According to [33] absenteeism and turnover are called the eighth lean concept. This step is basically targets on employee turnover and absenteeism rate are analyzed.

STEP 7: Apply lean tools and techniques to analyze data

The focus of lean techniques is on waste reduction. A set of relevant lean techniques suited to the garment industry will implemented to develop the future-state VSM of the line. Observing actual line behavior during the study period resulted in pinpointing key issues in the process line at the Factory.

Step 8: propose solution

All the research carried out along with analyzed system and finally the proposed frame work and other improvement techniques should be assessing in detail.

Step 9: Evaluate practical validation

Besides proposed theoretical analysis result implementation of lean tools is applied and the results are assessing in detail.

CHAPTER FOUR

4. CASE COMPANY DESCRIPTION

4.1. COMPANY DESCRIPTION

In this section the case company research has taken place is categorized by identifying the organization, its location and some of its background history, some of their products manufactured are clarified, their industrial deployment, working area measurements, current layout and available equipment and machinery. The production process of the factory is described, being afterwards its most important products or case product, flow of materials and line balance analyzed, productivity of worker, finally the waste of factory will identify and finally sets framework and improvement direction.

4.1.1. History

The case company Candy and Helen (C&H) garment starts manufacture by the Chinese owner the so called Mr. Chandima from 2015 up to 2018 but the factory cannot resist the market competition due to customer problem and production, since initially the company customer are not reliable and forces to market challenge, besides it even the customer are available the due date (promise day keeping) is not well managed, this leads the company to expense to export by plane since the lead time is beyond the promise date, due to the above problem the owner make to change privacy to Sumec international another owner on January 31/2018, this company is famous in garment sector, it has factory on Africa, East Europe and China, the new owner have changes the office staff members but the factory workers and other quality, maintenance & production activities are as is. The mode of production controls are not changes from previous trend plus the organization have no formal structure arrangement.

4.1.2. Products of company

The company has fifteen major production lines: the manufacturing line of the company is flexible and rearranges able to sew different garment products. This research focus on baby boy short manufacturing line, when the research was carried out the company was under the operation of baby boy shorts, polo "T" shirt and sport wear, so that the short sewing process is more difficult and parts to be sew are more in number and take long process steps so that the selection of this garment product can govern the other short processing items. The manufacturing line ranges products from shorts, polo "T" shirt, sport wear and dresses.



FIGURE 8: EXAMPLE OF COMPANY PRODUCTS

4.2. Factory Deployment

4.2.1. Industrial Area

C&H garment has a total area of 5500 m², and pay one dollar per month on single unit area. It is found on single shed on block number 12 of bole lemi industrial park. The factory divided in two floors: the ground floor, which is mainly used for storage, reception and loading of raw material, production process, and shipment and unloading of finished goods, including also the employee latrines, maintenance office, administration office, QC offices and at the first floor we encounter the top management main office, meeting room, Finance office. The Ground area production line is fifteen in number with an activity of: -

- Line 1,2,3, baby boy shorts
- Line 4,5,6,7,8, sport wear
- Line 9,10,11, polo “T” shirt area
- Line 12 is training line
- Line 13,14,15 null line by man power shortage and less number of machinery

The factory has three spreading and cutting tables, quality control tables(on each process line end table and at the middle line of before Ironing and final before packing); an ironing section; finished good quality checker and packing sections, an area to receive and relax garments for and from the sewing line; and an area to store finished goods

4.2.2. manufacturing Layout

The lay out of the company is well arranged for modern floor structure to manage easily. It has no hidden work area, less lighting area, rough surface on floor and short ceilings, and the current layout of the industrial plant is illustrated bellow with the different production section on floor area.

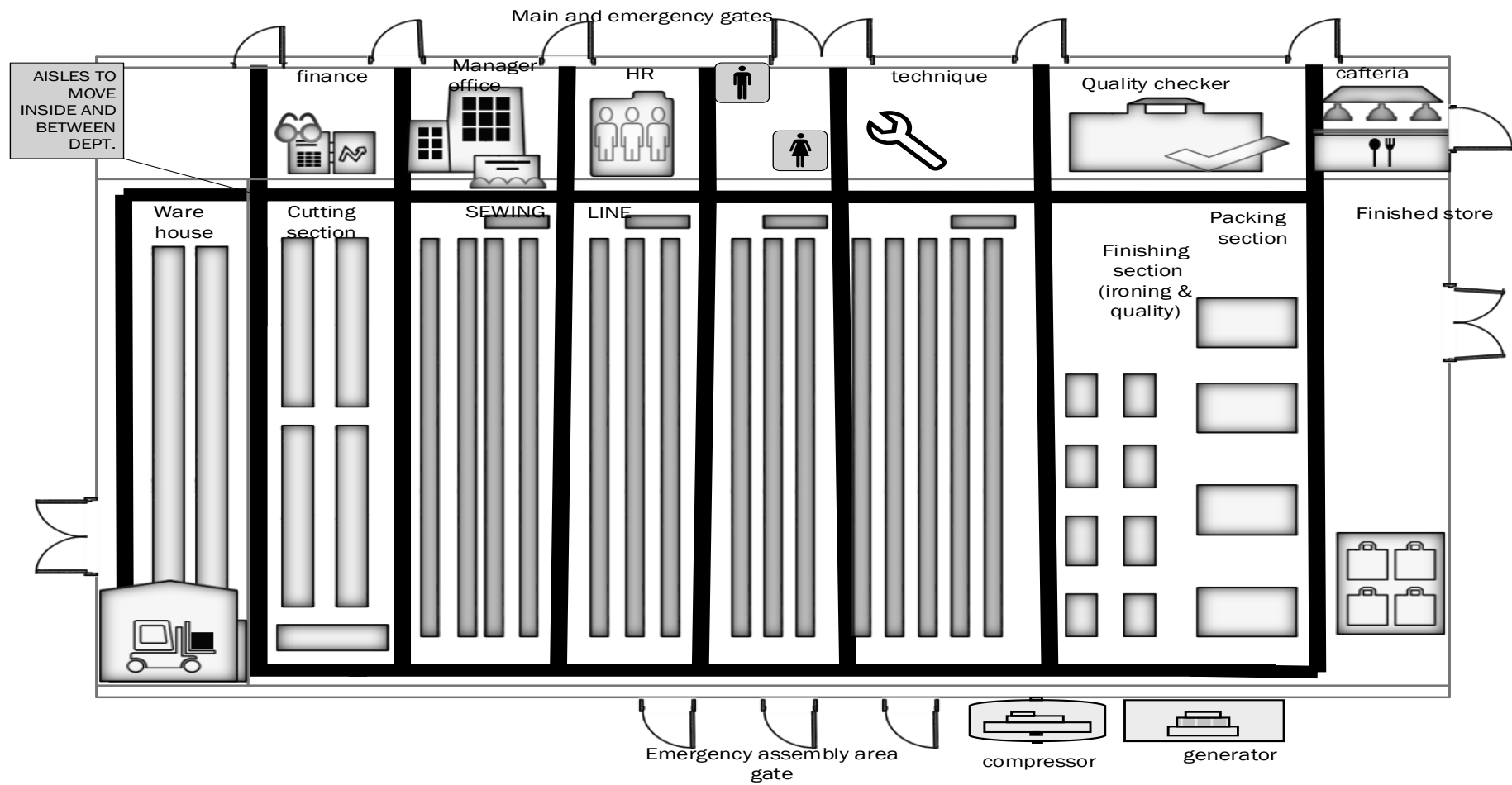


FIGURE 9: LAYOUT OF FACTORY

4.2.3. Equipment

There's a variety of equipment on the plant which machinery are available or in what quantity. The maintenance head and line maintenance have an idea to identify the machine types,

TABLE 6: FACTORY MACHINERY AND EQUIPMENT'S

s. no	Machine type	unit	quantity	description
1	Collar fixing machine	pcs	01	
2	Binder cutter machine	pcs	01	
3	Pocket fixing machine	pcs	01	
4	Label machine	pcs	02	Thermal
5	Cutting machine	pcs	02	
6	Pattern making machine	pcs	3	One machine with programmable input system
7	Flat over lock	pcs	18	
8	Feed off arm(MS)	pcs	18	
9	Bar tack	pcs	7	
10	Kahn shay	pcs	6	
11	Button stitch	pcs	12	
12	Button hole	pcs	17	
13	Double stitch	pcs	100	
14	Single single stitch	pcs	200	
15	Over lock	pcs	90	

The line supervisor has a responsibility to balance the process line based on customer order by time study on sample product.

4.3. Production Process Description

The sequence of activity carried out in production process is starts from cutting up to finished goods along with quality control activity. In the following picture we can see the key stages of the production process for baby boy shorts manufacturing line sequences.

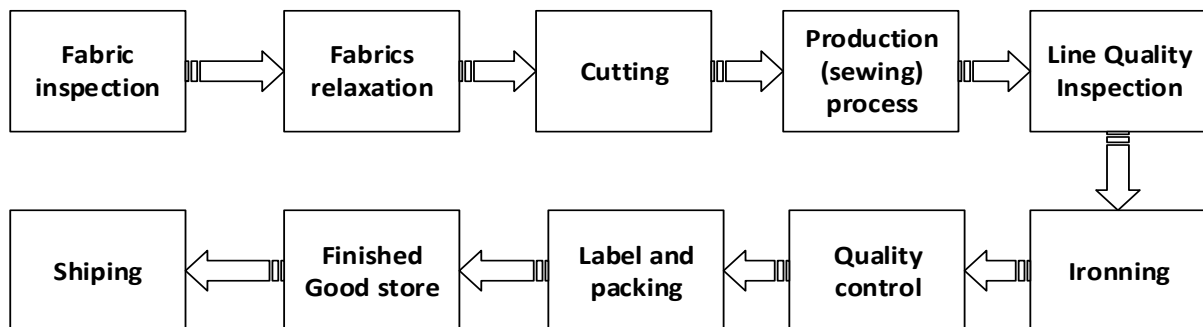


FIGURE 30: KEY STAGES OF THE PRODUCTION PROCESS

4.3.1. Cutting section

Before the cutting activity the raw fabrics should relax for 24hr, after relaxation time the sheet fabric spread over three tables, the spreading of relaxation cloth is doing manually by four

operators in individual table. They spread the fabric in the cutting table, forming layers according to the size stipulate. After finishing one roll make a separation mark thread since one roll may have different color from the other roll.

In cutting section the pattern is developed with a technical designer along with the order of production with a pattern sheet of how to cut the fabric in the most efficient way, reducing any waste of fabric. This pattern is set on top of the layers and the employees cut the fabric according to fit the pattern shape and circumference round area. The final cut fabrics in the process are identified with tags and put on the shelf waiting to enter the production line. The procedure of cutting activity in a factory is as follow: -

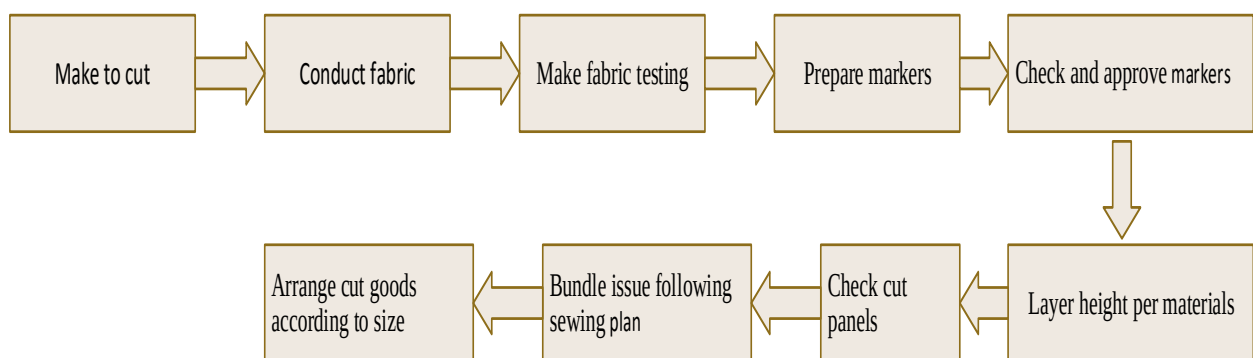


FIGURE 11: CUTTING SECTION PROCESS STEP



(a)

(b)

FIGURE 12: (A) CUTTING LAYERS

(B) FABRIC SPREADING SHEET

4.3.2. Production Line

After the fabric is cut into pieces, they enter the production line to be assemble. In the production line one line contains many operation, with a step wise process that have consequence approaches. Therefore, before entering the production line a careful time study

on sample product is conducted for balancing production line to be taken place and the machines that will be used must be set a lay out on efficient manner, so that the flow of material has the minimum interruptions as much as possible, ideally none interrupted. In our case research case the baby boy shorts line process is done by a step wise ways these activities are done with three groups the back part, the front part, finally combined parts. The process is cross check with the swatch card, this card contains accessory part of the fabrics other than main parts like, cord, fusion, etc. as shown below fig 13

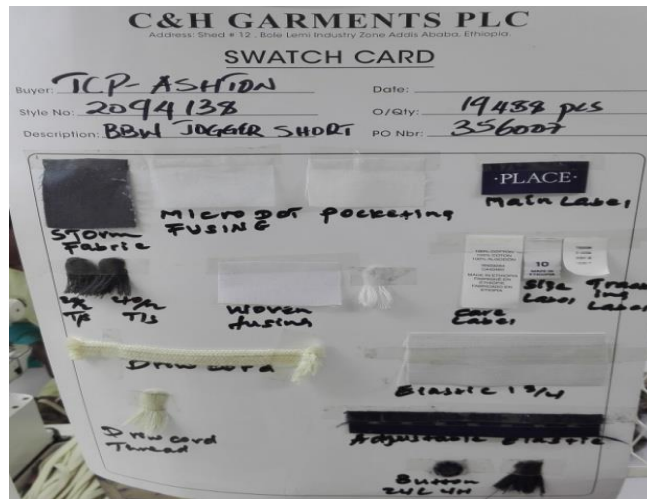


FIGURE 13: PRODUCT SWATCH CARD

The main reason for selection of this product is based on work complexity ;on floor observation the production line engaged with polo T shirt, baby shorts and sport wears among three baby short needs long time and large process varieties so selection of this product may governs all factors.

TABLE 7: THE PRODUCTION PROCESS FLOW STEPS

BACK PART	
PART LIST	MACHINE
Back rise	Over lock
Stitching on front part of back rise	Feed of arm
Size label stitching	Single stitch
Mark back pocket location	Manual
Back Pocket folding and ironing	Manual
Pocket lower part stitching	Single stitch
Pocket upper part stitching	manual
back pocket hem	double stitch

FRONT PART	
PART LIST	MACHINE
Front rise stitch	Over lock
Front rise safety stitch	Single stitch
Side pocket part preparation	Feed of arm
Attach pocket with front main part	Single stitch
"J" stitch	Double stitch
Side pocket French stitch	Single stitch
Care and tracking label attach	Single stitch

COMBINATION (back & front) PART	
Side hemming of front and back part	Over lock
Attach size label	Single stitch
Side hem safety double stitch	Feed off arm
Waist band fold and hem	Single stitch
Adjustable plastic and button place fusion, cloth placing & ironing	Manual
Waist stitch with main part	Double stitch
Draw cord place hemming	Button stitch
Open button	Button hole
Button stitching	Button stitch
Plastic cord hemming	Single stitch
Draw cord hemming	Single stitch
Adjustable cord stitching	Kahn shay
In seam with seam towards front	Double stitch
Main label attach	double stitch
Lower end hemming	Single stitch

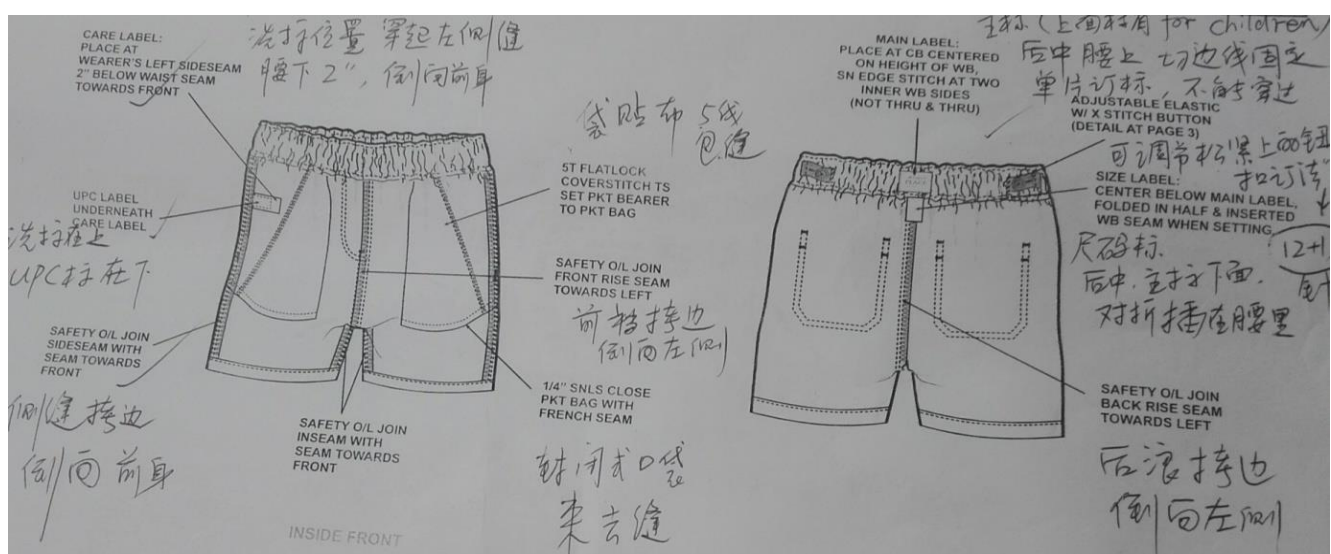


FIGURE 44: MAIN COMPONENT OF ORDER (CASE) PRODUCT

4.3.3. Ironing

The Ironing process helps to make the fabric surface laid down and stretch the pieces of garment, so that the ironing process are carefully done before put in hangers or box to be afterwards packed and shipped to finished goods store.

4.3.4. Packing and Shipping

In this final stage, the final garments are brought to the storage area in a carton by 150 pieces/carton ready to be placed in the transport van and shipped to the respective client, in export or foreign customer shipped with one container 40 feet size have 50,000 pieces, this quantity may vary according to the order amounts.

4.4. Inspection and Quality Control

After all the garment assembling, it goes to the inspection section to be revise one by one. In the case company it is found at four locations the first is in the mid line of production process, the second is on the front end of the line part of the productive process, third is after ironing and the final is before packing. The inspection and quality control take the garments that come out of the production line and examine them in all the areas with stitches for loose lines, bad sewing, any anomaly in the buttons, stampings, inside labels, etc. Generally, the quality control follows with a guide line for detail Analysis shown below: -

TABLE 8: PRODUCT PART INSPECTION GUIDELINE

INSPECTION PART
(A). TOP SECTION
Main label, Size (care) label, UPC label, Pocket bag, Button attachment, Button hole attachment, Elastic setting, Draw cord or belt
(B).CLOCK WISE CHECK
Front size, zip setting, ”J” stitch, waist band, Front pocket, side pocket crotch alignment, draw cord/belt, front leg panel, Bar tack, back rise, back yoke, back pocket, back pocket hem
(C) OTHERS
Fabric ways, panel way, thread size, fusing, sewing gauge, thread size, needle size

CHAPTER FIVE

5. CURRENT STATE VALUE ANALYSIS

5.1. PRODUCTION PROCESS ANALYSIS

In lean system to improve productivity analyzing the productive process with a critical view, with the intent of identifying wastes in the process and how to reduce them are critical concept and main goal .starting from material flow with the spaghetti diagram, map the value stream with a VSM, continuing by describing in depth how the line was balanced, identifying long cycle time process, and evaluating individual worker & line productivity, besides this, ways of how it will be improved with lean method .

5.1.1. SPAGHETTI DIAGRAM

The spaghetti diagram helps to determine the material flow of a product in the production process line from start to final destination of the plant. In depth observing different product has unique diagram it differs from product to product, depending on the complexity, operations required, type of material, machinery requirement, lay out of plant, type of material handling etc. The spaghetti diagram below is developed by considering that the material flow enters in one side of the production line and leaves out from the opposite side of the plant.

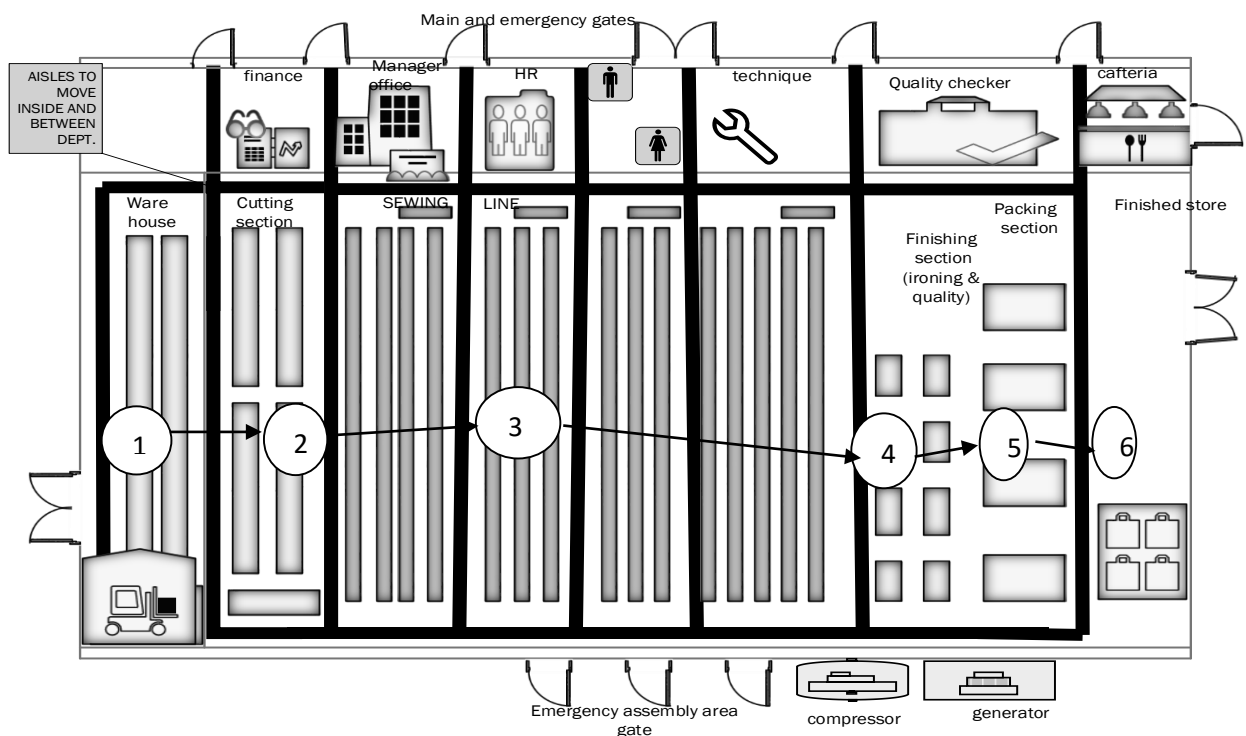


FIGURE 15: SPAGHETTI DIAGRAM (MATERIAL FLOW)

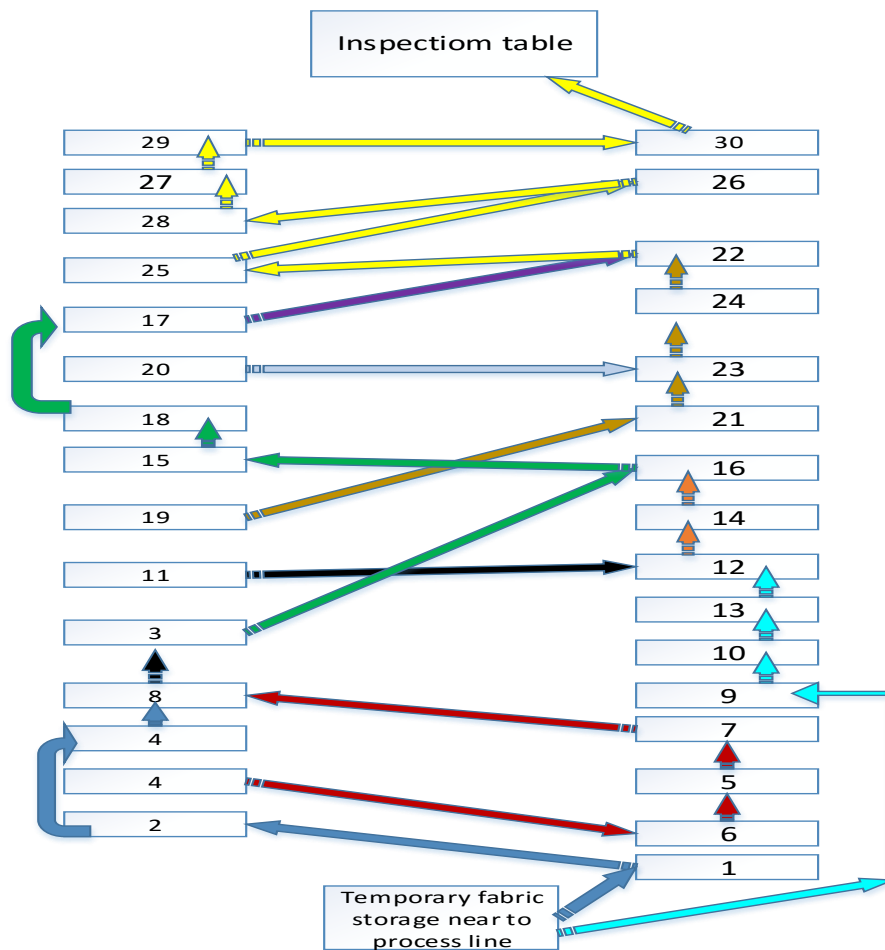


Fig 16 detail material flow on process line

As observed from the above figure 16&17 there was no reverse and complex inter connected flow of the production line it is a straight forward movement so, the availability of unnecessary movement and transport of materials is minimum, this implies the lay out does not need improvement or re-arrangement.

5.1.2. TAKT TIME CALCULATION

The company receives an order of 19000 pieces of baby boy shorts to deliver it with 30 day of lead time (promise day), the company works one shift operation of 8 working hour and one hour for lunch break. The takt time is calculated as follow

$$\text{TAKT TIME (time/unit)} = \frac{\text{Available production time per day (7 hr*60min)}}{\text{Customer demand per day (19000/30 day)}}$$

$$\text{Customer demand per day (19000/30 day)}$$

$$\text{TAKT TIME (time/unit)} = 420/634 = 0.6625 \text{ minute/unit} = 39.74 \text{ second}$$

5.1.3. CYCLE TIME

Cycle time is how frequently a finished unit actually comes off the end of your line or pacemaker cell. In this case, it includes all types of delays occurred while completing a job, as exemplified in the next formula

$$\begin{aligned} \text{Cycle time} = & \text{process time} + \text{setup time} + \text{waiting time} + \text{moving time} \\ & + \text{Inspection and rework time} + \text{delay} \text{-----Eqn.19} \end{aligned}$$

Cycle time and takt time should be balanced in parallel, with approximated time. Without this precaution the production may result in a late delivery to customer.

5.1.4. Line Balancing

The case product line in C&H garment has two main arranged manufacturing lines in parallel and a middle way to separate right and left lines for transfer of semi-finished garment, the baby boy shorts has 30 main operations, listed in the table below.

TABLE 9: OPERATIONS DESCRIPTION TABLE

OP/NO	OPERATION DESCRIPTION	AVERAGE TIME (S)	MACHINE	
001	Back rise	17	Over lock	BACK SIDE PART
002	Stitching on front part of back rise	35	Feed of arm	
003	Size label stitching	7.5	Single stitch	
004	Mark back pocket location + pocket fold and mark stitch place	23	Manual	
005	Back Pocket folding and ironing	21	Manual	
006	Pocket lower part stitching	14	Single stitch	
007	Pocket upper part stitching	19	Single stitch	
008	back pocket hem	15	double stitch	
009	Front rise stitch	20.46	Over lock	FRONT SIDE
010	Front rise safety stitch	16.98	Single stitch	
011	Side pocket part preparation	11.02	Single stitch	

012	Attach pocket with front main part	22.05	Single stitch	PART
013	“J” stitch	16.4	Double stitch	
014	Side pocket French stitch	54.85	Single stitch	
015	Care and tracking label attach	15	Single stitch	
016	Side hemming of front and back part	43.33	Over lock	COMBINATION PART OPERATION
017	Attach size label	16.15	Single stitch	
018	Side hem safety double stitch	25.0	Feed off arm	
019	Waist band fold and hem	13.97	Single stitch	
020	Adjustable plastic and button place fusion, cloth placing & ironing	24.85	Manual	
021	Waist stitch with main part	44.14	Double stitch	
022	Draw cord place hemming (black)	40.48	Button stitch	
023	Open button	13.98	Button hole	
024	Button stitching (buttoning)	14.4	Button stitch	
025	Plastic cord hemming four place	76.2	Single stitch	
026	Draw cord hemming with waist	59.42	Single stitch	
027	Adjustable cord stitching upper	20.35	Kahn shay	
028	Adjustable cord stitching lower	31.98	Kahn shay	
029	In seam with seam towards front	10.914	Over lock	
030	Lower end hemming	39.54	Single stitch	

Note:-The operation time Listed on table 8 are the cycle time

From process balance load analysis above the work station 14, 16, 21, 22, 25, 26, are above takt time level, These implies needs extra resource or shift the load to other low cycle time station. The line was balance with thirty operation operators and eleven type machines, according to the current situation balancing was carried out through different arithmetic steps as follow.

Step 1. Determine average process time, immediate predecessor and number of follower task

Task no	Average time(s)	Immediate predecessor	Number of follower task	Task no	Average time(s)	Immediate predecessor	Number of follower task
1	17	----	17	16	43.33	8.15	12
2	35	1	16	17	16.15	18	10
3	7.5	2	15	18	25	16	12
4	23	3	14	19	13.97	---	10
5	21	4	16	20	24.85	---	10
6	14	5	15	21	44.14	17,19,20	9
7	19	6	14	22	40.48	21	8
8	15	4,7	13	23	13.98	22	7
9	20.46	---	16	24	14.4	23	6
10	16.98	9	15	25	76.2	24	5
11	11.02	----	16	26	59.42	25	4
12	22.05	14	14	27	20.35	26	3
13	16.4	10	14	28	31.98	27	2
14	54.85	11	15	29	10.914	28	1
15	15	12,12	13	30	39.54	29	----

Step 2 determine cycle time

The cycle time in this case is determined by ranges with minimum and maximum times

Minimum cycle time= longest process time =76.2 second

Longest cycle time = total sum of process time=859.764

The cycle time should be between these two ranges in other way cycle time determined by

Cycle time = $\frac{\text{operating time}}{\text{Desired output}}$ = $\frac{(420\text{min} (25200 \text{ sec}))}{634 \text{ pieces}}$ =39.74 second

Desired output 634 pieces

This cycle time is below minimum cycle time so we prefer to take minimum cycle time period 76.2 sec. for cycle time analysis.

Step 3: - determine number of work station

$N = \text{Longest cycle time} / \text{cycle time} = 859.764 / 76.2 = 11$ number of work station

Step 4: - Arrange the work station

STATION	TASK	TASK IN SECOND	LINE BALANCE DELAY	STATION	TASK	TASK IN SECOND	LINE BALANCE
1	1	17	59.2	6	16	43.33	32.87
	2	35	24.2		20	24.85	8.02**
	5	21	3.2**	7	19	13.97	62.23
2	9	20.46	55.74		21	44.14	18.09
	11	11.02	44.72		24	14.4	3.69**
	3	7.5	37.22	8	22	40.48	35.72
	6	14	23.22		23	13.98	21.74**
	10	16.98	6.24**	9	25	76.2	0**
3	14	54.85	21.35	10	26	59.42	16.78
	7	19	2.35**		29	10.914	5.866**
4	4	23	53.2	11	28	31.98	44.22
	12	22.05	31.15		30	39.54	4.68**
	13	16.4	14.75**	Note ** indicate idle time			
5	8	15	61.2				
	15	15	46.2				
	18	25	21.2				
	17	16.15	5.05**				

Step 5: - determine balance delay and efficiency

Idle time = 75.586 second

Total work station time = $11 \times 76.2 = 838.2$ second

Balance delay = $\text{Idle time} / \text{total work station time} \times 100 = 9.018$

Efficiency = $100 - \text{balance delay} = 100 - 9.018 = \underline{\underline{90.982}}$

The general balanced Work stations are as follow

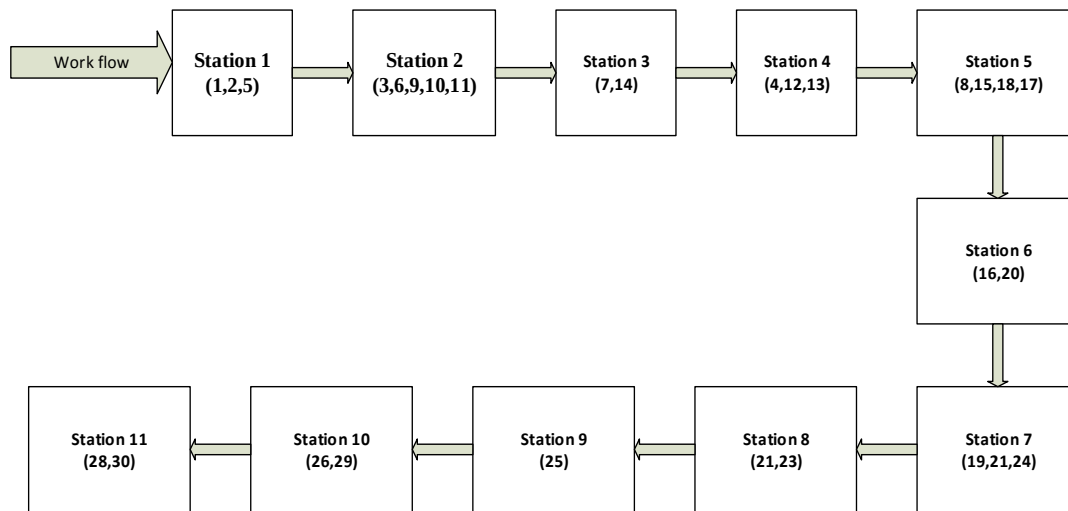


FIGURE 17: WORK STATION CELLULAR ARRANGEMENT AND FLOW

Note: - in lean principle the workers expect to be multi skill and capable of run more than one operation.

5.1.5. COMPARE CAPACITY AND CUSTOMER DEMAND

One important question when doing a VSM analysis is whether or not the process is able to meet the customer demand – and how well the process is equipped to handle increasing demand levels. In order to do this successfully, we need to study the capacity of the bottle neck, since this will determine the maximum pace of the process. Thus, we simply compare the cycle time for the bottle neck with the takt time (current or future).

$$\text{Over capacity} = \text{Takt time} - C/T_{\text{Bottle neck}} \text{ -----Eqn.20}$$

In our case, this gives us an excess time of 36.46 seconds per cycle. This can be translated into number of products by simply multiplying with the number of cycles for the given period (customer demand). Another possibility is to calculate the maximum production output (volume) for a given period and compare it to the customer demand.

$$\text{Maximum output} = \text{Available time} * C/T_{\text{Bottle neck}} \text{ -----Eqn.21}$$

This gives us the *Max output* = 420min * 60s/min / 76.2s = 331 units

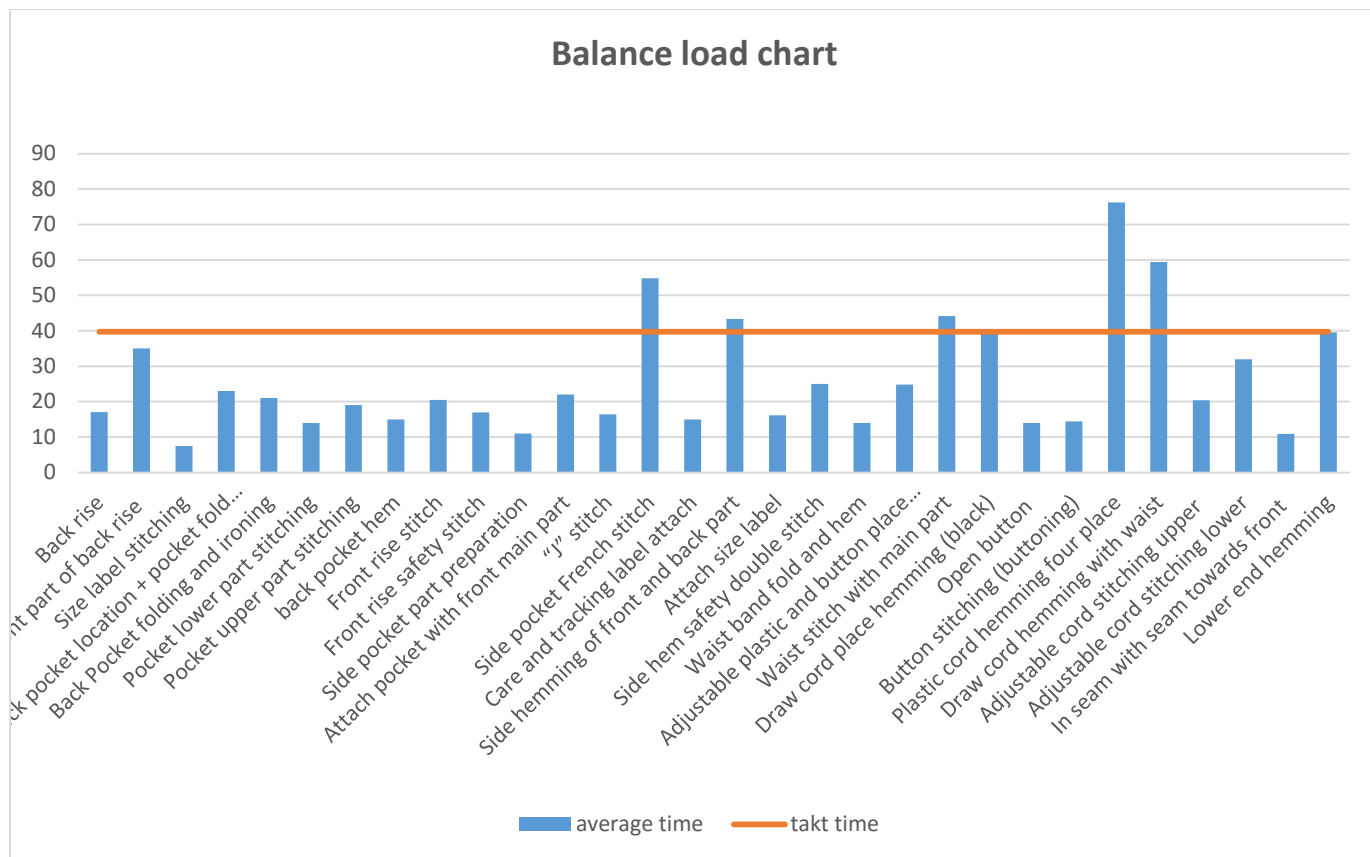


FIGURE 18: PROCESS BALANCE LOAD GRAPH

From above process load the process was arranged evenly by combining the activities, in this procedure the workers expected to be multi skill and can operate more activities based on this, By re balancing the process five activities are bottle neck that determine the process cycle time, in order to minimize activity, the lines should balance and rearranged either combining activity or addition of extra resources. Analysis becomes as follow fig 19 below.

Table -10 work station re arrangement

OP/NO	OPERATION DESCRIPTION	MACHINE	AVERAGE TIMES(S)	TAKT TIME	TIME DIFFERENCE
1	Back rise + Size label stitching	Over lock +Single stitch	17	39.74	22.74
2	Stitching on front part of back rise	Feed of arm	35	39.74	4.74
3					
4	Mark back pocket location + pocket fold and mark stitch place	Manual	23	39.74	16.74
5	Back Pocket folding and ironing + Pocket lower part stitching	Manual + Single stitch	21	39.74	18.74
6					
7	Pocket upper part stitching + back pocket hem	Single stitch + double stitch	19	39.74	20.74
8					
9	Front rise stitch + Front rise safety stitch	Over lock +Single stitch	20.46	39.74	19.28
10					
11	Side pocket part preparation + Attach pocket with front main part	Single stitch	11.02	39.74	28.72
12					
13	“J” stitch	Double stitch	16.4	39.74	23.34
14	Side pocket French stitch + Care and tracking label attach	Single stitch	54.85	39.74	-15.11
15	Care and tracking label attach + Side pocket French stitch	Single stitch	15	39.74	24.74
16	Side hemming of front and back part +Attach size label	Over lock +Single stitch	43.33	39.74	-3.59
17	Attach size label +Side hemming of front and back part	Single stitch +over lock	16.15	39.74	23.59
18	Side hem safety double stitch +Waist band fold and hem	Feed off arm +single stitch	25	39.74	14.74
19					
20	Adjustable plastic and button place fusion, cloth placing & ironing	manual	24.85	39.74	14.89
21	Waist stitch with main part	Double stitch	44.14	39.74	-4.4
22	Draw cord place hemming (black)	Button stitch	40.48	39.74	-0.74
23	Open button + Adjustable cord stitching upper	Button hole + Kahn shay	13.98	39.74	25.76
24	Button stitching (buttoning)	Button stitch	14.4	39.74	25.34
25	Plastic cord hemming four place	Single stitch	76.2	39.74	-36.46
26	Draw cord hemming with waist +In seam with seam towards front	Single stitch+ Over lock	59.42	39.74	-19.68
27					
28	Adjustable cord stitching lower	Kahn shay	31.98	39.74	7.76
29	In seam with seam towards front + Draw cord hemming with waist	Over lock +Single stitch	10.914	39.74	28.826
30	Lower end hemming	Single stitch	39.54	39.74	0.2

Table 11. After re-arrange the work station manpower is arrangement

OP/NO	OPERATION COMBINATION	AVERAGE TIMES(S)	TAKT TIME	TIME DIFFERENCE
1	1+3	17	39.74	22.74
2	2	35	39.74	4.74
3	0	0	0	0
4	4	23	39.74	16.74
5	5+6	35	39.74	4.74
6	0	0	0	0
7	7+8	34	39.74	5.74
8	0	0	0	0
9	9+10	20.46	39.74	19.28
10	0	0	0	0
11	11+12	11.02	39.74	28.72
12	0	0	0	0
13	13	16.4	39.74	23.34
14	14+15	34.925	39.74	4.815
15	14+15	34.925	39.74	4.815
16	16+17	29.74	39.74	10
17	16+17	29.774	39.74	9.966
18	18+19	25	39.74	14.74
19	0	0	0	0
20	20+21	34.495	39.74	5.245
21	20+21	34.495	39.74	5.245
22	22+24	27.44	39.74	12.3
23	23+27	13.98	39.74	25.76
24	22+24	27.44	39.74	12.3
25	25	38.1	39.74	1.64
25	25	38.1	39.74	1.64
26	26+29	35.167	39.74	4.573
27	0	0	0	0
28	28	31.98	39.74	7.76
29	26+29	35.167	39.74	4.573
30	30	39.54	39.74	0.2

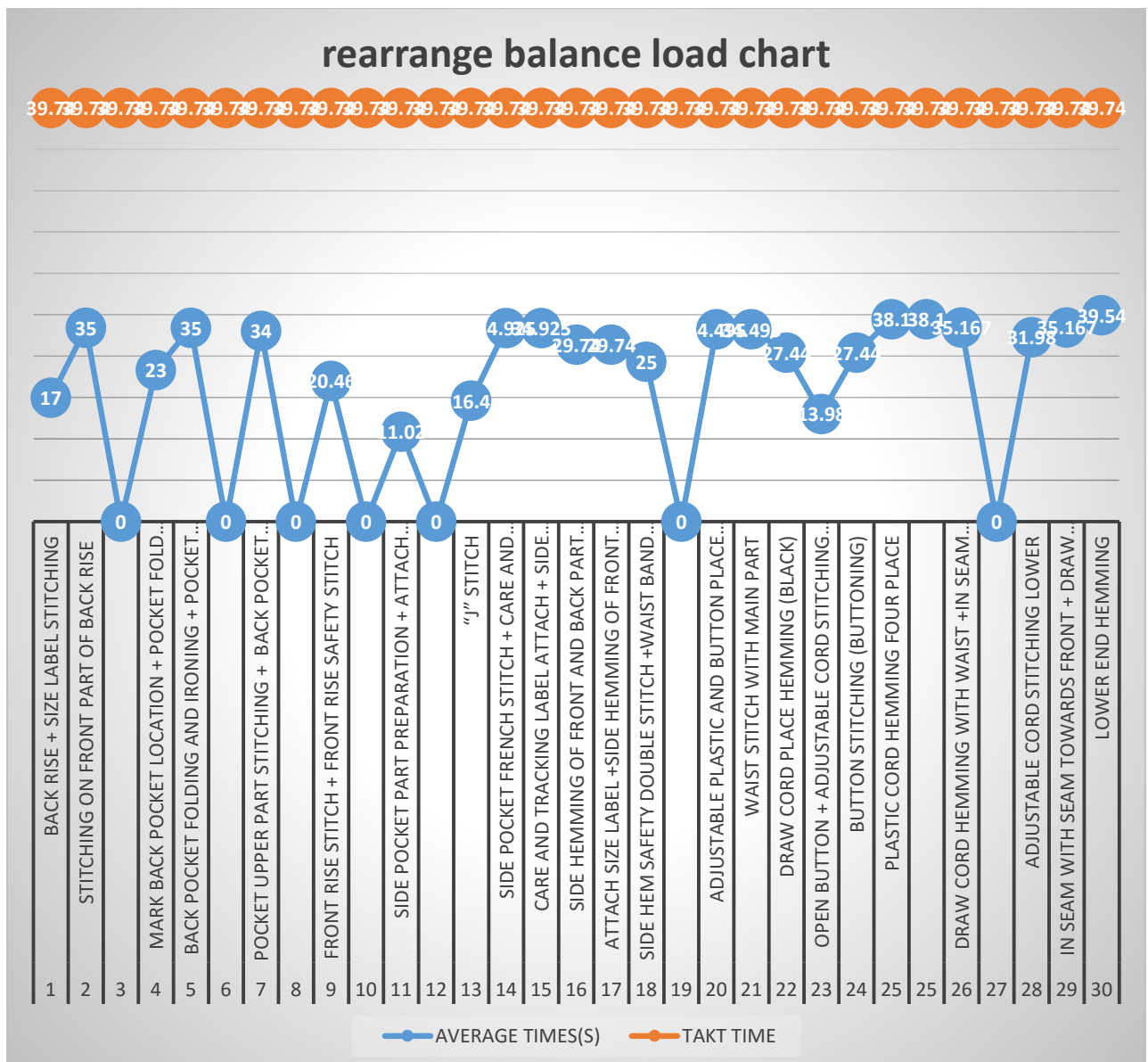


FIGURE 19: MODIFIED BALANCE LOAD GRAPH

From figure above out of 30 activity table by balancing their activity 7 activity become free from work station but one activity needs extra resource, those 6 activities are shifted and add to another implies un balance arrangement of individual work activity the efficiency in man power utilization decrease by 20% from original balance. The maximum production output from leveled arrangement is $=420 \times 60 / 39.74 = 634$ units this means an increase of 48% in productivity and fulfill daily expected target production rate.

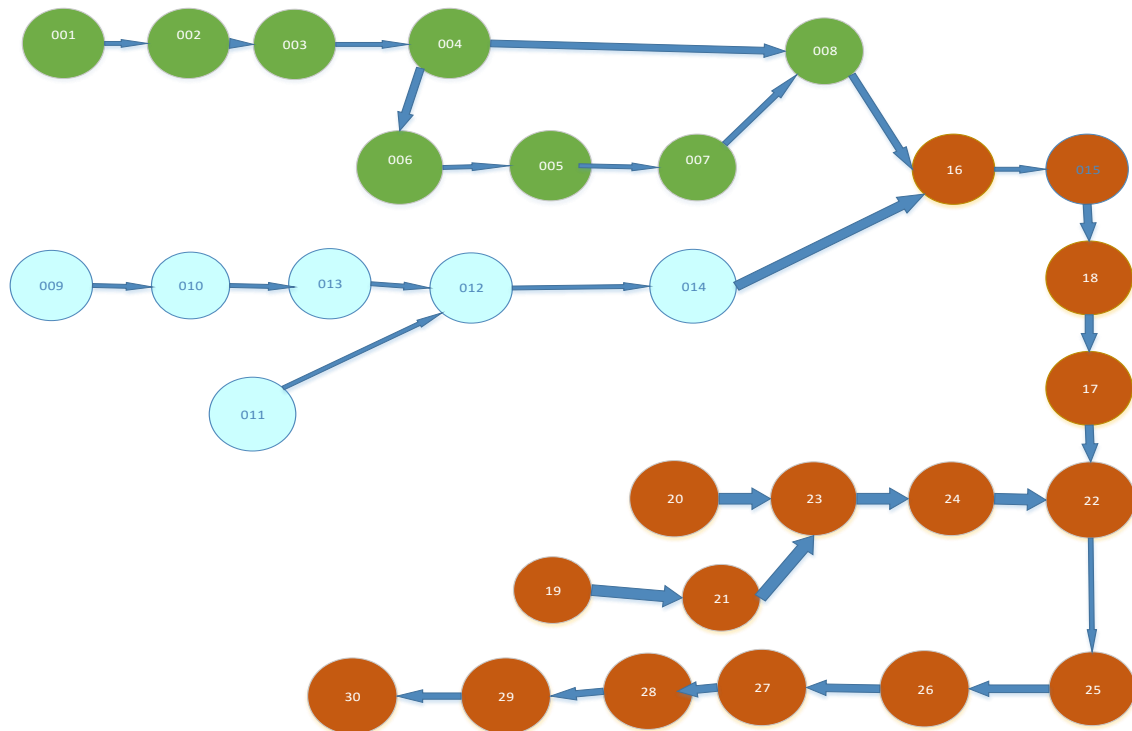


FIGURE 20: PROCESS ANALYSIS FLOWCHART

To conclude the efficiency and balance of the process line with respect to client demand potential, primarily the Takt time should be determine. The normal available working hour is 8 hours each day, and minus one hour for lunch time from normal working hour, being this specific order of production of 19000 pieces' baby boy shorts, the order starts from 15/03/2018 and the due date is 18/04/2018 with thirty days, with working time of six days per week. To keep the due date plus deliver in thirty days, the takt time is rated as above is 0.6625min/unit.

5.1.6. Value Stream Mapping

A lean value stream includes all activities, required to fulfill a customer request from order to delivery. The product family to be mapped was done by gathering information while walking along the actual pathways of material and information flows and time line of the process with the help of a stopwatch.

Table 12 Required data for current VSM																		
s.no	Process Name	Machine cycle time (C/T) (sec)	Uptime (%)	change over time	population	inventory level	Available time	takt time (s)	waste time (s)							Total time (s)	NVA time (s)	VA time (s)
									transport	waiting	inventory	defect	over production	over processing	un necessary motion			
1	Raw material store (relaxation period)		100	0	1	1500	22500	39.74	120	0	59610	0	0	0	0	86520	120	
2	Pre-production (cutting)	10800	100	0	9	1008	22500	39.74	0	0	40057.92	0	25	0	0	10825	25	10800
3	Assembly	76.2	100	0	31	492	22500	39.74	120	300	19552.08	1344	40	0	30	1910.2	1834	76.2
4	quality check and inspection	23.3	100	0	3	140	22500	39.74	0	50	5563.6	0	0	0	0	73.3	50	23.3
5	ironing	24	100	0	3	290	22500	39.74	60	110	11524.6	0	0	0	0	194	170	24
6	quality control	20	100	0	3	260	22500	39.74	0	60	10332.4	82	0	0	0	162	142	20
7	label and packing	24	100	0	6	75	22500	39.74	30	0	0980.5	0	0	0	0	54	30	24
8	shipment			0	1		22500	39.74										
																249360	151992.1	97367.5

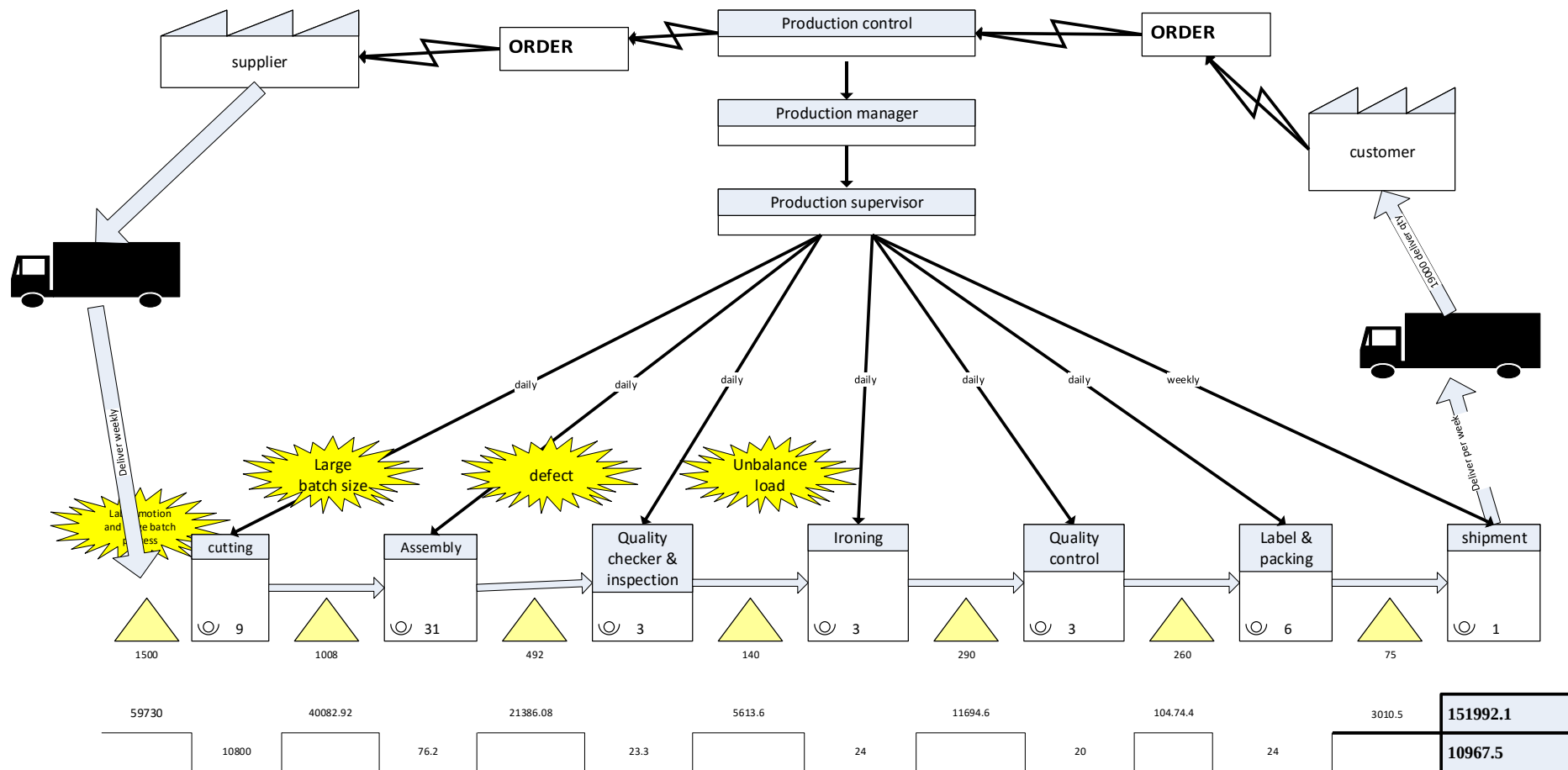


FIGURE 21: CURRENT STATE VALUE STREAM MAP

From above current VSM the **VA** (value added) time is 10967.5 second and **NVA** (non-value added) time is 151992.1second, the **LT** (lead time) becomes 162935.6 second.

5.1.7. ANALYZING THE CURRENT STATE MAP

According to [34] the percentage ratio of VA to LT should be analyzed, based on this the company to be competitive on global market the ratio should be more than 25%.

The process efficiency of current state VSM is = VA/LT -----Eqn.22

$$= 10967.5/162935.6*100$$

$$\underline{=6.73\%}$$

However, to improve the ratio, the NVA time should be reduced and the VD time needs to be increased, which was the objective of this study. When analyzing the current state map, we are mainly looking for one thing: Balance! This is a word that has several meanings. First of all, we want to have a balance between the customer demand and the total capacity of the process. Furthermore, we want to have balance between the operations, mainly in terms of process time. Also, we want to have balance in the sequencing of products, to assure a predictable and steady production pace.

5.1.8. ANALYZE PROCESS CAPACITY

Our first step to ensure this balance is to compare the customer takt time to the cycle times of the operations in the process. If any operation has a cycle time that is longer than the takt time, we will not be able to supply a sufficient amount of products to meet the customer demand. In our case, we do have a cycle time that is longer than the takt time; process number 14, 16, 21, 22, 25, 26, are above takt time.

An effective way of doing this assessment is to create a capacity analysis diagram as illustrated in Figure 18. For this diagram, we need to calculate the average cycle time and the average changeover time for each operation according to the following formulae.

$$\text{Average C/T} = \text{Cycle time} / \text{Average batch size} = 76.2/1 = 76.2$$

5.1.9. IDENTIFY BOTTLENECK

The information flow in total system is done by paper base but the foreign customer and supplier exchange information through electronics (cell phone and social media). As observed

from the work process inventory (WIP) high level of inventory is accumulated after raw material store between cutting and assembly, assembly and quality checker and inspection, ironing and quality control, quality control and labeling and packages are crucial events.

5.2. PROBLEMS IDENTIFICATION

In this subtitle it was describes the main observed problems that were identified in the case company, and afterwards analyzing in detail to direct next approaches for their solution.

5.2.1. LOOKING FOR WASTE

A – DEFECT AND REJECT PRODUCT PROBLEM

The company have high amount of reject and defect products as observe in table 10 below the average defect and reject product is 13%. This figure shows the line end final inspection but in between the production line quality checker and operator defect reworking are not visible for management. The main defect types are uncut thread, visible top stitch, skipped stitch, miss stitch line, the root cause for this problem is analyses by fish bone diagram as shown below fig 23.

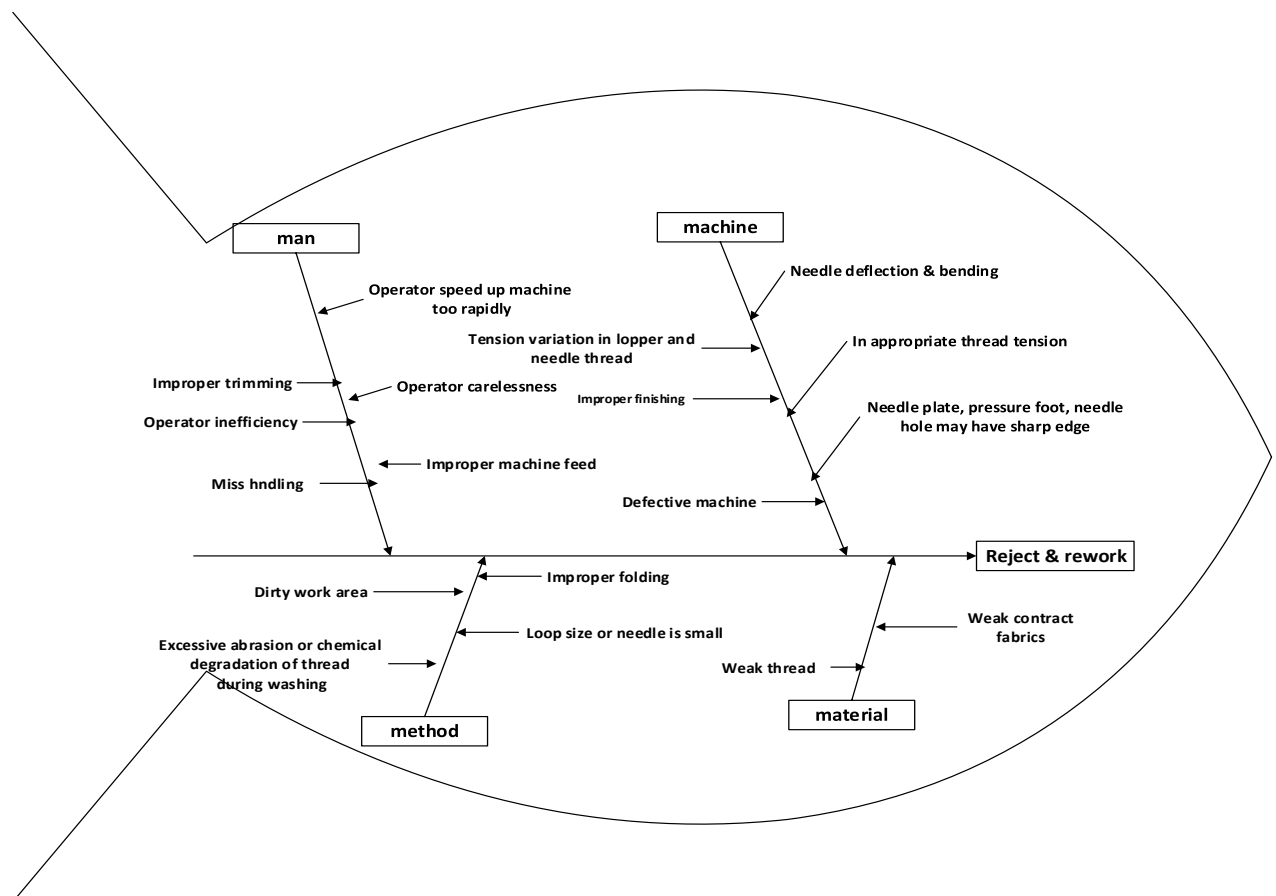


FIGURE 22: FISH BONE (CAUSE AND EFFECT) DIAGRAM OF DEFECT AND REJECT

TABLE 13: DEFECT AND REJECT PRODUCT (SOURCE COMPANY PROFILE)

DATE	STYLE NO	STYLE	PO#	COLOUR	SIZE	TOTAL PRODUCT	QUALITY PRODUCT	REWORK	REJECT	%GE OF REWORK& REJECT
28/2/2018	2094138	6301	352423	Fin Gray	18-24/2T	435	356	74	5	18.2
1/3/2018	2094138	6301	352423	Fin Gray	18-24/2T	421	375	39	7	10.9
2/3/2018	2094138	6301	352423	Fin Gray	18-24/2T	438	366	63	9	16.4
5/3/2018	2094138	6301	352423	Fin Gray	18-24/2T	483	432	43	8	10.6
6/3/2018	2094138	6301	352423	Fin Gray	18-24/2T	438	375	55	8	14.4
7/3/2018	2094138	6301	352423	Fin Gray	18-24/2T	361	322	29	10	10.8
8/3/2018	2094138	6301	352423	Fin Gray	18-24/2T	370	331	27	12	10.5
9/3/2018	2094138	6301	352423	Fin Gray	18-24/2T	536	487	43	6	9.1
10/3/2018	2094138	6301	352423	Fin Gray	18-24/2T	432	343	77	12	20.6
12/3/2018	2094138	6301	352423	Fin Gray	18-24/2T	534	469	54	11	12.2
13/03/2018	2094138	6301	352423	Fin Gray	18-24/2T	535	471	56	8	12.0
14/03/2018	2094138	6301	352423	Fin Gray	18-24/2T	533	473	52	8	11.3
15/03/2018	2094138	6301	352423	Fin Gray	18-24/2T	562	497	61	4	11.6
16/3/2018	2094138	6301	352423	Fin Gray	45-55/3T	340	287	44	9	15.6
17/3/2018	2094138	6301	352423	Fin Gray	45-55/3T	400	360	26	14	10.0
19/3/2018	2094138	6301	352423	Fin Gray	45-55/3T	300	269	16	15	10.3
20/3/2018	2094138	6301	352423	Fin Gray	45-55/3T	453	404	42	7	10.8
21/3/2018	2094138	6301	352423	Fin Gray	45-55/3T	385	331	45	9	14.0
22/3/2018	2094138	6301	352423	Fin Gray	45-55/3T	306	269	29	8	12.1
23/3/2018	2094138	6301	352423	Fin Gray	45-55/3T	436	363	67	6	16.7
24/3/2018	2094138	6301	352423	Fin Gray	45-55/3T	382	332	45	5	13.1
26/3/2018	2094138	6301	352423	Fin Gray	45-55/3T	530	473	51	6	10.8
27/3/2018	2094138	6301	352423	Fin Gray	45-55/3T	375	322	41	12	14.1
28/03/2018	2094138	6301	352423	Fin Gray	45-55/3T	377	332	36	9	11.9
29/03/2018	2094138	6301	352423	Fin Gray	45-55/3T	446	384	51	11	13.9
30/03/2018	2094138	6301	352423	Fin Gray	45-55/3T	379	317	49	13	16.4

From defect and rework analysis averagely 13% defect was extracted under operation, this means 47 pieces' rework and 9 pieces' reject this take 22.4minute takt time rate.

B. INVENTORY LEVEL

From current state value stream map there was high level of WIP inventory levels the maximum expected output is 634 pieces but on process line there was 3765 pieces on process line inventory.



FIGURE 23: HIGH LEVEL OF INVENTORY ON CUTTING SECTION

From this high WIP inventory by safety and buffer stock in addition to maximum out put the extra cycle inventory level on line it becomes 841 pieces, but 2924 extra inventory level on line.

C. TRANSPORT WASTE

As observed from the spaghetti diagram figure 16 it does not need improvement since there was no reverse flow of the production line means it was a straight forward movement so, there availability of unnecessary movement and transport of materials is minimum, but transport of fabrics to cutting and from cutting to assembly, from quality inspection to ironing has small amount wastes.

D.OVER PROCESSING

In the case company after the initial pattern and sample product is developed the quality checker practice to check the dimension colour, label type, according to the production order further activities unless design change happen considered as waste and need rework so the waste type is almost negligible.

E. OVER PRODUCTION

when considering over production it mostly related with defect material, as the defect increases the production section request replacement for defects by pad called “replacement requisition” after it ratify the store issue the fabrics by ITRS (internal transfer slip) in this time by considering future damage part sometimes extra product and damaged parts will sell in final budget year ceasing time this waste happen in cutting and assembly line.

F. MOTION.

The unnecessary operator motion is random and difficult to record its tendency but mostly this unnecessary motion occur at the beginning, of the operation side most workers take the ready fabrics from shelf and sit this process is repeated duty but in other way the exiting, lunch& break time the worker devotes with on way talk, long wearing set up, fetching water, this situation account as trend and normal activity even the management have no concern to correct the activity.

G. WAITING

The waiting mostly happens in the line by the information gap in production line changes and machine failure but in machine failure the machines is replaced by other machine and the failed machine maintain without interruption, this makes the waiting time to minimize. But from observation the set up time when transfer from one order to another order needs more than 3 days first day sample preparation second and third day train each operation to workers and technician.

From looking a waste the level of wastes or degree of waste types according to the observed quantitative data of Fig.25, the degree of main wastes are below.

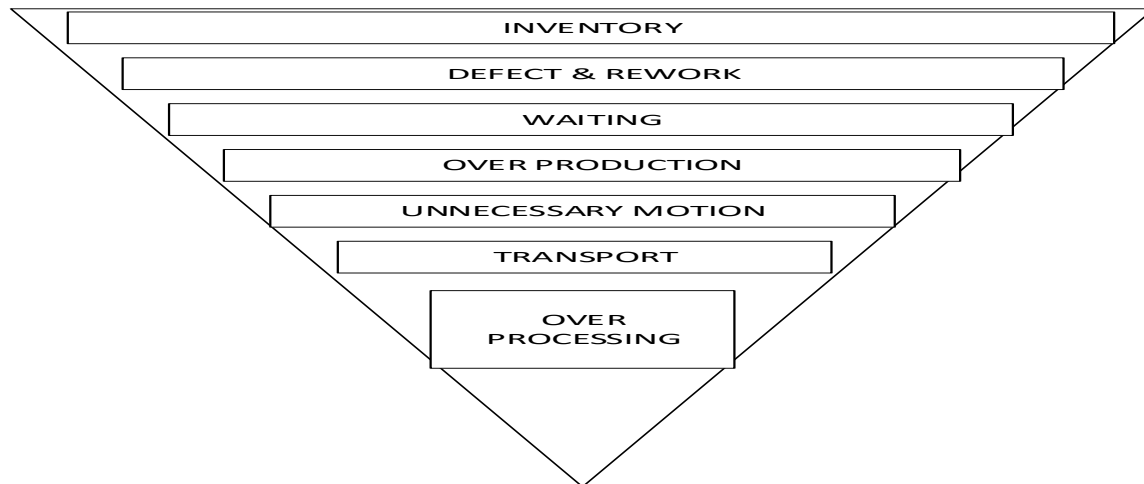


FIGURE 24: COMPANY WASTES LEVEL

5.2.2. un organize work area

The sewing section have well-arranged material and machine but in the inspection and cutting section the off cut cloths and rejects are scattered over floor and under tables by cartons.



FIGURE 25: DAMAGE AND OFF CUT FABRICS OVER FLOOR

So that the application of 5S Auditing should be applied over the factory causes for this problem this is caused by

- Less management commitment to follow up the factory floor
- The worker gives less attention and creates environmental adaptation

So that the management should rearrange the damage parts and off cut cloths in proper out of sight location and bundle in proper manner, as a lean principle the factory should practice a 5S practice and the work area should be clear for movement,

5.2.3. Production control system

The production lines the process proceeds in three line (L1, L2, L3) each line has similar product is loaded, by analyzing one-hour production data of each line, there is high variation on productivity due to lack of performance indicators meanings most worker suggest for their personal incentive, the line supervisor have no measure to revise the individual efficiency, generally main problems are: -

- Individual operator efficiency, are the only indicator but production line efficiency is not determined.
- Incidence of defects Operator's is not managed
- The company have no uniform production management and control structure with similar style, fabric type, similar machine, and similar worker status there is big line output as shown below table 12.

TABLE 14: LINE PRODUCTIVITY COMPARISON

DATE	LINE ONE			LINE TWO			LINE THREE		
	Sub Total	Total	WORKING HOUR	Sub Total	Total	WORKING HOUR	Sub Total	Total	WORKING HOUR
15-03-18	14	184	5	99	135	3	115	272	7
	170		8	36		3	157		7
16-03-18	260	386	8	60	285	6	97	330	4
	126		6	225		6	233		4
17-03-18	270	270	7	223	372	8	183	425	8
	0		0	149		7	242		8

19-03-18	229	382	8	351	353	8	273	539	8
	153		8	2		2	266		8
20-03-18	287	287	8	343	400	8	58	369	8
	0		0	57		6	311		8
21-03-18	197	244	7	304	520	8	231	571	8
	47		4	216		8	340		8
22-03-18	298	470	8	333	421	8	71	431	8
	172		8	88		8	360		8
2/3/18	238	480	8	72	103	3	77	373	7
	242		8	31		2	296		7
5/3/18	131	131	5	159	399	8	170	870	8
	0		0	240		8	700		8
6/3/18	172	250	8	383	416	8	169	420	8
	78		6	33		6	251		8
7/3/18	114	180	8	149	152	7	136	348	7
	66		7	3		1	212		8
8/3/18	95	202	8	74	258	7	105	369	8
	107		7	184		7	264		8
9/33/18	225	263	8	122	394	8	169	436	7
	38		8	272		8	267		8
10/3/18	225	263	8	218	349	8	360	500	7
	38		8	131		8	140		8
11/3/18	271	298	8	201	385	8	231	528	8
	27		7	184		8	297		8
12/3/18	163	163	8	85	109	8	208	485	8
	0		0	24		6	277		8
13/03/18	195	389	8	178	247	8	278	509	8
	194		8	69		7	231		8
average		285	6.5		312	6.56		457	7.56
Rate/hr.	44 pieces per hour			48 pieces per hour			61 pieces per hour		

As we observe from above with similar situation there is a big productivity rate difference line three has 27.9% and 21.3% high production rate from line one and two respectively.

The target amount is not well defined from line capacity in the case product (baby shorts) target production per line is 350 but from 8hr full production time the line production capacity is indicated below show high deviation.

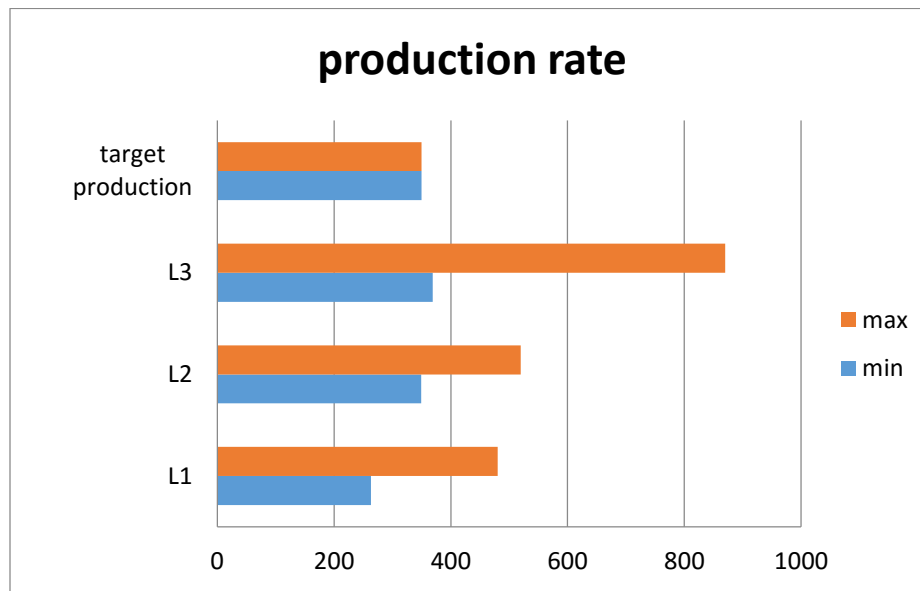


FIGURE 26: PRODUCTION RATE RELATIVE TO TARGET AMOUNT

In production control problem the management should set uniform job evaluation and Control mechanism for a sake to gain productive work environment. In the beginning of a production order, it is given a production sheet to each employee with the operation that he'll be performing and, at each hour, he should fill how many times he performed each operation. With this, the operations manager (line supervisor) would determine the productive time and the efficiency at each hour, and write them in the label "MIN." and "percentage %", respectively, returning the sheet to workers.

5.2.4. Quality Management problem

The major defects identified above is due to the quality control section therefore all operations preceding this quality check have already been done, wasting time and material or even requiring rework, just because there wasn't a more careful inspection, in addition to it ,The nonexistence of any type of records registering the type of defects and its occurrences brings the unlikeliness of understanding which operations originate more defects, hence its possible reasons, such as machinery malfunction or operative error. Therefore, there's no way of knowing exactly where to act and improve even the final defect report is not well revised, it acts as trend.

5.2.5. MACHINE BEHAVIOR

All machines in a company have short life time since the factory doesn't have long production history, the company have Zoje and Jack type sewing machines, both marks are more efficient and active but in manipulating by leg Zoje type need knee support horizontally (see fig 28 a below), this makes fatigue on leg and ergonomically it has adverse effect over knee. Most workers are not voluntary to operate this machine.



(A)

(B)

FIGURE 27: (A) ZOJE (ONE LOWER LEG PEDAL & KNEE SUPPORT) (B) JACK (ONE FOR WARD AND BACK WARD PEDAL)

5.3. THE EIGHTH WASTE FACTOR ANALYSIS

The productivity improvement is not achieved by only lean method but analysis of the work condition, machine behavior, methods of work procedure, worker Absenteeism, turn over, shop floor management, management educational status, trend of manufacturing system (philosophy) & experience, organization structure should analyze well since work culture has great impact on productivity.

5.3.1. Worker Absenteeism and turn over

The company makes line 12 for new joining worker training area, the training basically delivers according to the section they will assign (quality with quality, production with operating machine, maintenance machine element) the quality and maintenance workers take a training by on the job

training from their senior worker on production line, but the production worker practices basic sewing machine operation up to prohibition period.

The company has five grade workers according to their performance, number of operating machine, skill of technical knowhow and worker critical operations, their benefit packages also depend on the workers grade. The company assigns 200 birr as non-absenteeism bonus to overcome

The absenteeism problem. The following table indicate C&H garment worker payment, grade, and benefit packages.

TABLE 15 WORKER BENEFIT PACKAGE PROCEDURE

s. no	job type	Grade	basic salary	performance	Attendance + bonus	Total salary	Description
1	Machine operator	A+	1300	700	200	2200	can operate all basic machines with production efficiency/can do critical operations/can do technician jobs
2	Machine operator	A	750	550	200	1500	can operate all basic machines with production efficiency/can do critical operation and achieve target
3	Machine operator	B	750	350	200	1300	can operate twoormore machines with 85% efficiency/ can do major operations achieve target
4	Machine operator	C	750	150	200	1100	75% efficiency/can stitch Assigned operation and Achieve target
5	Machine operator	D	750		200	950	on training but can understand machine handling and do simple operations

The absenteeism data is taken from three consecutive month period data i.e. December, January& February from individual worker monthly attendance sheet. The report shows below indicate there is high rate of absenteeism that is more than 11.4% the absenteeism is mostly exaggerated by maternal and sick leave. The minimum rate is 3.3% and with high rate 42.3 (NB. this is due to 164-day maternal leave). The high rate of absenteeism is seen as due to with non-reason absenteeism.

TABLE 16: ABSENTEEISM RATE DATA

position	no of worker			total working day	total worker active date	Maternal & marital leave	permission	absent	sick leave	total absent	total absenteeism rate	Forced absenteeism	non forced absenteeism
	male	female	total										
Clerk	15	10	25	620	511	164	2	89	7	262	42.3	27.6	14.7
Cutting	26	77	103	2534	2222	54	0	224	25	303	12.0	3.1	8.8
Finishing	51	94	145	3576	2896	39	6	463	32	540	15.1	2.0	13.1
General	2	27	29	718	550	24	0	92	5	121	16.9	4.0	12.8
Line-1	9	94	103	2548	2239	26	0	215	27	268	10.5	2.1	8.4
Line-2	13	136	149	3674	3047	24	1	344	35	404	11.0	1.6	9.4
Line-3	20	129	149	3680	3076	11	6	439	39	495	13.5	1.4	12.1
Line-4	3	42	45	1096	871	0	0	168	4	172	15.7	0.4	15.3
Line-5	5	37	42	1008	829	0	0	130	9	139	13.8	0.9	12.9
Line-6	4	73	77	1912	1698	26	4	155	14	199	10.4	2.1	8.3
Line-7	6	68	74	1836	1459	26	0	245	12	283	15.4	2.1	13.3
Line-8	8	61	69	1716	1435	0	0	228	27	255	14.9	1.6	13.3
Line-9	6	80	86	2124	1776	20	0	296	11	327	15.4	1.5	13.9
Line-10	5	85	90	2212	1980	95	0	109	28	232	10.5	5.6	4.9
Line-11	9	381	390	9420	1897	40	0	252	23	315	3.3	0.7	2.7
Line-13	5	59	64	1594	1135	24	0	268	9	301	18.9	2.1	16.8
Maintenance	6	42	48	1194	968	0	0	171	15	186	15.6	1.3	14.3
QC	19	47	66	1608	1429	0	2	164	14	180	11.2	0.9	10.3
Warehouse	4	54	58	1490	1245	10	0	153	12	175	11.7	1.5	10.3
summary	82	708	790	18974	9660	300	8	1707	139	2154	11.4	2.3	9.0
percentage						1.6%	0.0422%	9%	0.73%				

Shift from 8:00AM to 5PM time. In one shift there is a working time of 8 hour. Average number of workers in the shop floor= 420; working day in a year 300; total absence day by taking only non-reasonable absence only 2154 with three-month data means 30 man per day.

Operation time = total work hr. – (lunch time& break time) = 8 hr-1hr= 7.00 hr

Total human hour = average workers*working hr. =420*7=2940hr/shift/day

Annual absence time = number of working hour per day* number absence day
= 7*30*300= 63000 hr.

Annual human hour = number of working hour per day* average number of worker*total working days in a year = 7.0*420*300 = **882,000 hr/year.**

Absenteeism hour /year = average absenteeism per day * annual working = 30*300*7

= 63,000 hr./Year.

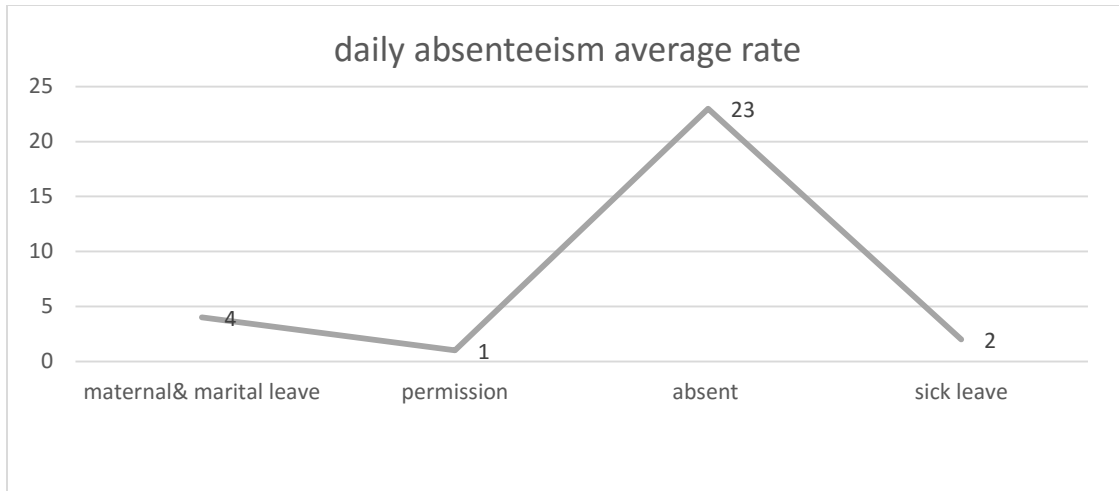


FIGURE 28: ABSENTEEISM RATE COMPARISON GRAPH

As initial data collection method in turnover, it is recommended to take the new management historical data from December to march (as shown below)

TABLE 17 TURNOVER RATE PER MONTH

s. no	month	Number of worker	turn over	New recruit	Description
1	December	540	38	24	7.04% turn over
2	January	520	73	31	14.04% turn over
3	February	523	24	75	4.6% turn over
Average		528	135	44	8.6% turn over

One of main problem in the garment and textile factory is more labor intensive nature, besides this the turn over and absenteeism has great impact over factory productivity, as shown in above analysis all department absenteeism. Among the reasons, the company not address the cause even individual workers have no tangible reason on absenteeism. The problem is that, this flow of people leaving creates the necessity of finding new worker, which implies a lot of work, time and training costs are required to hire new employee. This high turnover and absenteeism makes the company major reasons to hire new staff particularly the operators working in different sections. The main causes of absenteeism and turnover are shown in cause and effect diagram below.

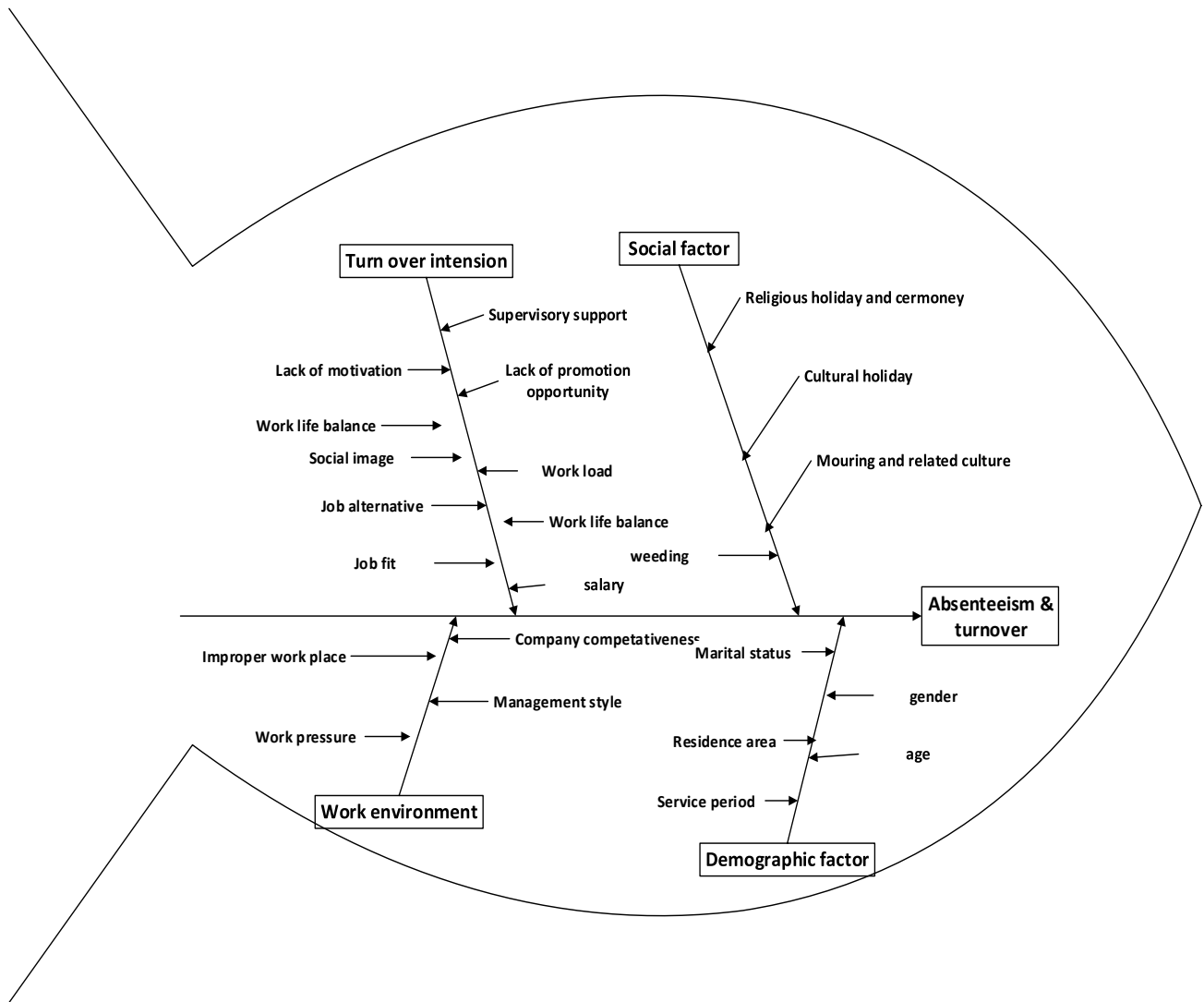


FIGURE 29: ABSENTEEISM AND TURNOVER CAUSES FISH BONE DIAGRAM

5.4. 5Why Analysis

Based on VSM analysis the wastes tendency is identified according to the degree of impacts, but to forecast solution for Root Causes of Various Wastes should be primary concern, then we found root causes of these wastes by applying 5 why analysis, for 5why analysis the highest waste and influential types should eliminate primarily. In addition to this the eighth lean waste (absenteeism and turn over) should be analyzed according to the lean tool and techniques.

TABLE 18: 5WHY ANALYSIS OF FACTORY BASIC THREE WASTES

WASTES	WHY 1	WHY 2	WHY 3	WHY 4	ROOT CAUSE	SOLUTION
Unnecessary Inventory	Unnecessary WIP Inventory	Low efficiency Less management concern	Lack of expert worker	Lack of training	Lack of effective training & motivation And production control	. HEIJUNKA (Level Scheduling) . Just in Time . kanban system . Single –minute exchange of dies
			Lack of sincerity	Lack of motivation Lack of effective control		
Defect and Rework	Find fault lately	Information gap			Information gap, less skill worker, qc system	POKA YOKE, controlling
	Lack of expert worker	Lack of training & motivation			Lack of training & motivation	Training , motivation & instruction for workers properly
Absenteeism &turnover	High rate of absenteeism	Lack of effective training	No formal training	Less management concern	No training section	Training ,motivation

CHAPTER SIX

6. THE LEAN FUTURE STATE IMPLEMENTATION AND PRODUCTION IMPROVEMENT METHOD.

The final concern of research after the problems and concern areas identified will be set a critical solution for production improvement and how to apply the lean tools for main problems.

6.1. waste elimination

The technique to find solutions to the problems identified, also defining an action to be applied, will be based on downward movements in terms of their happening frequency, this means critically needs to minimize the inventory level, defect rate, and absenteeism rates.

6.2. DETERMINING NUMBER OF KANBAN

To minimize the WIP level Kanban system is one method, Before proceed to future state VSM the number of Kanban cards should be determined, in addition to it the process safety and buffer stock should be determined in case company the demand has no variation so that the buffer stock is null, but in safety stock according to the daily production rate is calculated as follow,

Cycle stock= (replenishment time) *(production rate) *(1+ α), where α is safety factor = 0.05

Replenishment time(RT) = planning time +queening time + production + delivery time, in this paper the production and deliver times consider together as 7hr time, the planning time is 2hr, queening time is 0.5hr so that the RT time is 9.5hr, the production rate from average production data is 475 but maximum capacity 634 by estimating mid-way that is 555 per day,

Cycle stock=9.5hr *555 units/day*1.05 = 790units

Safety stock (s.s.) =Z*s. d where Z=service level value at 95% service level z=1.65

SS=1.65*125.6=207 units

Buffer stock since there is constant demand, the buffer stock is null So that total stock becomes 997 units, based on this the number of Kanban can be calculated as follow

Number of Kanban= (maximum stock /lot size), in our case_the lot size is 150 units

Number of Kanban =997/150=6.65=**7 Kanban**

The future state VSM is developed based on current VSM waste rate critical solutions, the table 19 below describes the final justifications

Table 19:- current state VSM modified events

A.WIP inventory minimization

s.no	Process Name	initial inventory	improve inventory	justification
1	Raw material store (relaxation period)	1500	0	The raw material should deliver immediately like JIT on cutting process by pre relaxation of fabrics this makes the inventory level becomes null on process line.
2	Pre-production (cutting)	1008	790	The raw material to be cut per day should contain cycle stock amount means 790pcs.
3	Assembly	492	362	From assembly to label and packing the process line should process the sum of cycle stock, safety stock, buffer stock & daily production rate based on this it becomes 997 pcs, but the rate of material availability on each spot is determined through cycle time rate. Based on this the individual & total sum time rate of the production line rate determines each spot inventory level.
4	quality check and inspection	140	111	
5	ironing	290	114	
6	quality control	260	95	
7	label and packing	75	114	

B.TRANSPORT MINIMIZATION

s.no	process	initial	improved	JUSTIFICATION
1	Raw material store (relaxation period)	120	60	The raw material transport from store to cutting machine through far right wall side door ,so to minimize it by making new door at the mid of the store side the transport time will reduce by 50%.
2	Assembly	120	120	To reduce transport waste the assembly and ironing it needs to change lay out and machine arrangement so it is better to left as it is.
3	ironing	60	60	
4	label and packing	30	15	The raw material transport from store to cutting machine through far left wall side door ,so to minimize it by making new door at the mid of the store side the transport time will reduce by 50%.

c. over production

s.no	process	initial	improved	JUSTIFICATION
1	Pre- production (cutting)	25	0	After applying Kanban system the extra material to be cut will stop so that the waste will cease.
2	Assembly	40	0	

To quantify other wastes, it is difficult but suggest solution and recommendations, which helps to improve the NVA time to increase output rate.

6.2.1. FUTURE STATE VALUE STREAM MAP

Table 20:- VSM future state data

Required data for future VSM																		
s.no	Process Name	Machine cycle time (C/T) (sec)	Uptime (%)	change over time	popula tion	inventory level	Available time	takt time (s)	waste time (s)							Total time (s)	NVA time (s)	VA time (s)
									transport	waiting	inventory	defect	over prdn.	over processing	un necessary motion			
1	Raw material store (relaxation period)	0	100	0	1	0	22500	39.74	60	0	0	0	0	0	0	60	60	0
2	Pre production (cutting)	10800	100	0	9	634	22500	39.74	0	0	25195.16	0	0	0	0	35995.16	25195.16	10800
3	Assembly	76.2	100	0	31	165	22500	39.74	120	300	6557.1	1344	0	0	15	8412.3	8336.1	76.2
4	quality check and inspection	23.3	100	0	3	51	22500	39.74	0	50	2026.74	0	0	0	0	2100.04	2076.74	23.3
5	ironning	24	100	0	3	52	22500	39.74	60	110	2066.48	0	0	0	0	2260.48	2236.48	24
6	quality control	20	100	0	3	44	22500	39.74	0	60	1748.56	82	0	0	0	1910.56	1890.56	20
7	label and packing	24	100	0	6	52	22500	39.74	15	0	2066.48	0	0	0	0	2105.48	2081.48	24
8	shipment			0	1		22500	39.74			0							
									255	520	39661	1426	0	0	15	52844.02	41876.52	10967.5

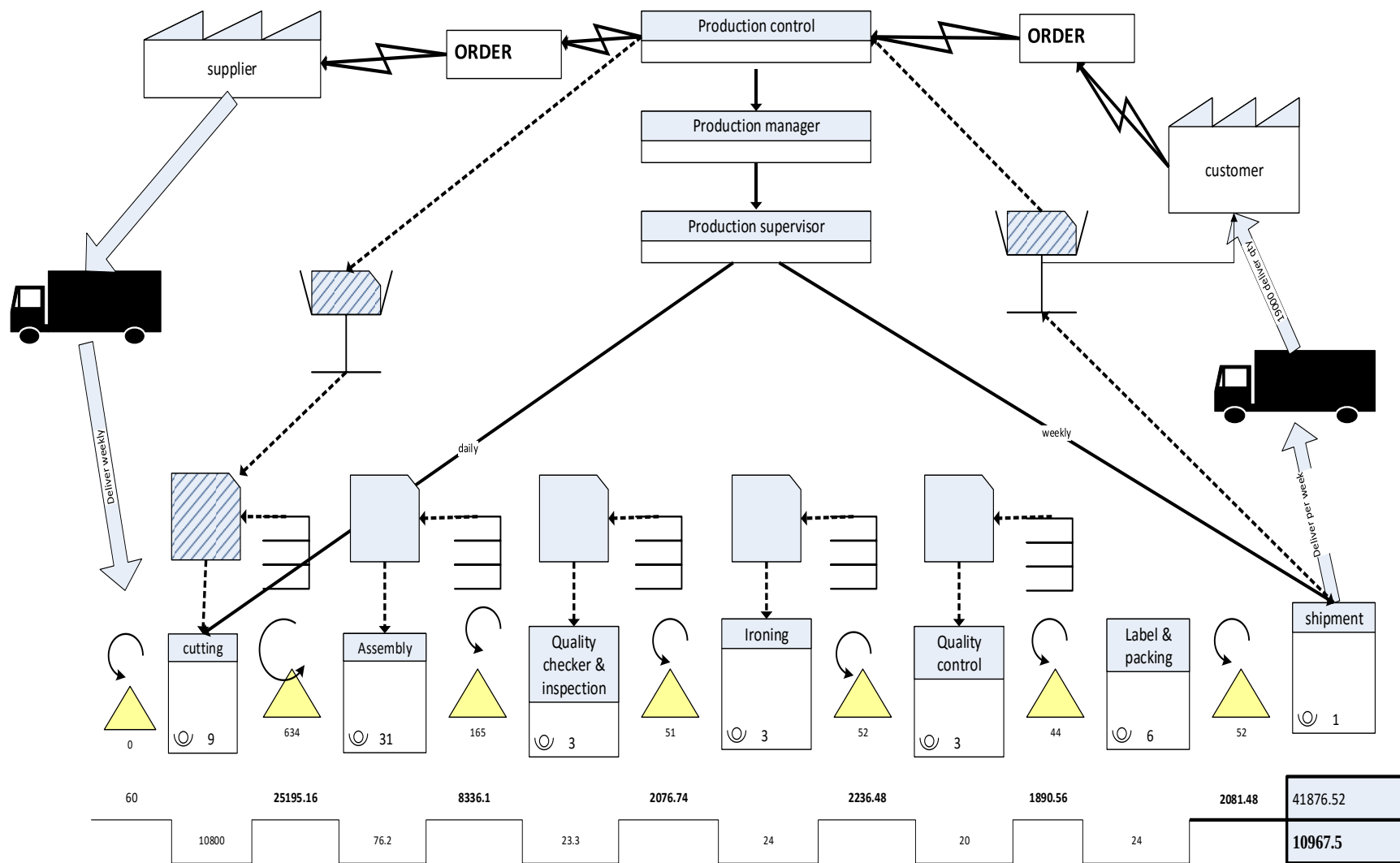


FIGURE 30: FUTURE STATE MAP

The system efficiency of the current state map is 6.73% but the future state map is 20.75% the efficiency increase by 14.02% the WIP inventory level is decrease from 3765 to 998 units by 73.5%. So this propose future state map have more advantages than the current state map.

6.3. 5WHY METHOD

To eliminate error and defects in a process poka yoke is best method for beginners these concept is not advisable since with single person without responsibility can interrupt the production so that 5WHY method is versatile step in Toyota Company to remove defects. Before applying the steps in reduction of defect and rework (quality) primarily the company should have a data and quality standard on a company so that to stays in business with current product quality satisfies its customers need at the price they are prepared to pay. so the defect decreases through

- Make quality work as every employees' responsibility.
- Develop quality benefit package and punishment system.
- Periodical report on quality should apply rather than final hour report.
- Develop quality circle for further to mainstream quality worker.
- Always quality activity should have interpreted by academician on quality position.
- Defect protection should be the primary concern than correcting.

In managing the defect check list for inspection parameters and reports like packing material, records of swatch cards, records of daily QC report, records of cutting problem report, records of inspection report etc.

Record all faults found at final inspection for immediate correction and to identify need for prevention specific stage of production, these faults should record properly before address to recommended department.

TABLE 21: DEFECT REGISTRATION SHEET

Date	Defect Type	Section	Model	Operation	Responsible	Remark

After the defects are well recorded the Defect category and percentage of defectives in each department should be identified in order to identify the tendency through which the defect causes to make correction action in order to eliminate permanently.

TABLE 22: FINAL DEFECT CATEGORY REPORT SHEETS

Defect category report sheet																						
DATE	fabrics defect	off cut defect	Thread Tension	Slip stitch	Broken stitch	Miss matched sewing thread	Roping	wrong Interlining placement	Puckering	Improper Fly shape	Improper rolling part	Fusing shining marks	Button Attachment defects	Uneven fly shape	Uneven Top Stitch	Uneven Raw Margin	Exposed Raw stitch	Label Attachment	Measurement out	Others	Total Checked Pieces	Total Defective Pieces

6.4. Implementing Five “S” method

Non organized work place arrangement in cutting and around store should be arranged properly, but 5s methods application may not restrict on single event or sections only this may to expand in whole company according to the level of existence and lean applicability. To practice it the company should follow the general 5s implementing guide lines of Toyota as follow fig 33.

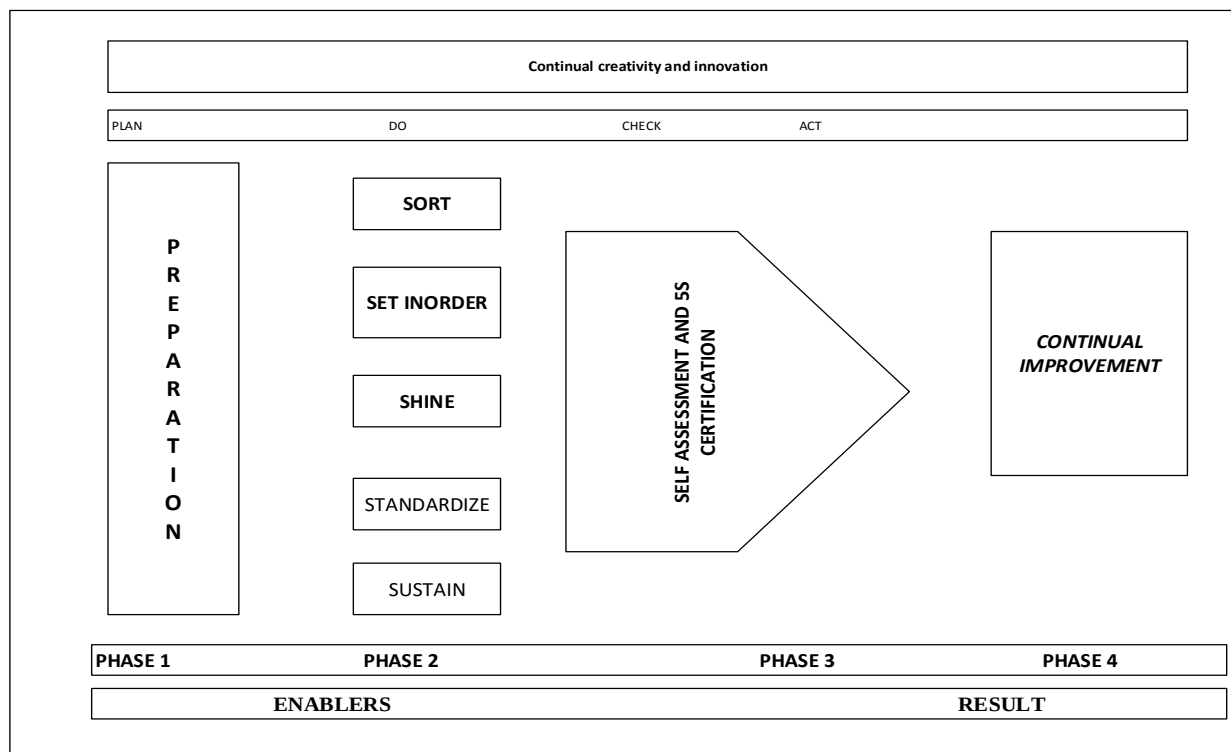


FIGURE 31:5S IMPLEMENTATION FRAME WORK

The implementation of 5s is not the final outcome so that the applicability should be revised periodically by 5s audit should practice.

6.5. HUMAN FACTOR IMPROVEMENT

To reduce the employee absenteeism, the following control plan is necessary and should be monitored closely by the management.

I. mainstream the company environment:

- Labour laws must be implemented in letter and spirit
- Improve working conditions
- Medical help must be provided within the plant itself.
- Transport facilities must be provided for all garment employees.
- Incentives scheme must be given by the management for star performers.
- Harassment must be brought the notice of the police and form committee to protect and follow the burden and cultural fear.

II. Respect for People

- Respect: (We respect others, don't side with ethnic group, religious, and citizen, make every effort to understand each other, take and give responsibility and do best to build mutual trust.)
- Teamwork: (every worker should consider the output is a cumulative measure of team work so that everyone can helps each other, stimulate personal and professional growth, share the opportunities of development and maximize individual and team performance).

III. Add value to the organization by developing your people and partners

1. Grow leaders who thoroughly understand the work, live the philosophy, and teach it to others.
2. Develop exceptional people and teams who follow your company's philosophy.
3. Respect your extended network of partners and suppliers by challenging them and helping them to improve the company culture.

IV. Training type

- Most of the training type in garment factory are operational training but mostly the technique in addition the worker should know basic parts and simple gauging and function of parts of a machine.
- Operators should be trained for at least three to four operations of their respective work cells. This will help to rotate operators between different operations.
- Develop formal structural training section this section not only for new joined worker it helps to advance the existing worker and management.
- Before joining the routine (formal) activities of garment, the operator should train and produce a complete apparel that confirm confidential completion for next job.

V. MOTIVATION

One method to motivate employees is cellular manufacturing, this system helps the operators to work in multiple operations in rotation. So there is no complying that someone is doing a difficult operation and others are working in easier operations. On the other hand, this is not possible in batch production because of specific allocated work for the whole day. Operators are treated as a group inside the cell so their combined effort is to do better and produce more. Likewise, operators cannot work carelessly because they will be immediately caught by the next operator inside the cell, so the combined result of all these factors motivates them to do better in each step.

VI. WORK BALANCING BETWEEN OPERATORS

One of the challenge in garment industry is division of work between operators. The work should be divided in such a way that each operator should get equal work load. This will motivate operators in their work as a result of which there is improvement in productivity.

6.6. production control system

I. Individual efficiency

The first problem identified was the lack of performance indicators such as individual operator efficiency, production line efficiency or incidence of defects are the major concern. so that Operator's efficiency is manually evaluated. In the beginning of a production order, it is given a

production sheet below to each employee with the operation that will be performing and, at each hour, it shows how many times he/she performed each operation. With this, the operations manager would determine the productive time and the efficiency at each hour, and write them in the label “MIN.” and “%”, respectively, returning the sheet to workers.

TABLE 23: INDIVIDUAL EFFICIENCY CONTROL FORMAT

No	Name	Date-----										
Operation no	Description	plan target-----										
s.no	Employees name	8AM	9AM	10AM	11AM	12AM	2PM	3PM	4PM	3AM	PERFORMANCE	MEASURE
1												
2												

ii) Create right process

The Creation of right process done by continuous process flow to bring problems to the surface, use the “pull” system to avoid overproduction, make level off the workload between employees, build a culture of stopping to fix problems, to get quality right from the first, standardize the work in each operation and make sincere visual control over all process.

iii) Process step modification

From the current base of process flow in manufacturing by re arranging the steps the minimum work processing route would develop by line supervisors.

IV) MACHINE SELECTION

In order to increase the efficiency of the worker the selection of machine type and ergonomically less tiredness should be considerable, in our case two measures are vital: -

- The Jack type machine should be allocating primary in lay out arrangement since it recovers the adverse feature.
- As mention in analysis the jack type machine may not be adequate so that to recover the ergonomic impact over the productivity the industrial knee pad (see fig. below) should distribute to Zoje type machine operator.



FIGURE 32: INDUSTRIAL KNEE PAD

6.7. RESULT ANALYSIS

The research output is to make productive changes from current state to the expected future state so that in order to finalize the extent to which the result of the research figure out should be expressed deeply, in the existing system, operators start producing parts continuously at their full efficiency irrespective of the requirement of succeeding operation. Due to this there is huge WIP inventory in between processes, which creates problems because as the WIP inventory increases, the chances of mistakes also increase. Once the problems are noticed during processing these will be corrected immediately which minimizes the cost of quality.

6.7.1. Comparison of Production Time

Production time of the C&H garment will have reduced by 3.46 minutes (i.e. approximately 47.8%). This has been achieved by line balancing all operation and bottle neck activity removing.

6.7.2. Comparison of Number of Operation

The number of operation needed to complete a product in normal trend with one operator one activity trend is 32 operators by excluding technical quality line supervisor but in line balancing less processing times activities are combined and the number of activities are merged to some extent, due to this the number of operator reduced to 26, this means 18.75%. The number of needed to complete a job is reduced by eliminating some non-value added operations from the process.

6.7.3. Comparison of Information Flow

In existing layout, the production line is very long, starting from preparatory to the end of assembly. Because of this, communication and information flow is difficult and for each and every

thing supervisor has to walk around the line frequently. In case of new layout (cellular layout) the information flow is effective and quick. Because, the group of people who are in the same cell, works in compact area where each operator is in direct contact with other operator of the cell and they know each other's job inside the cell. This makes information flow fast and accurate.

6.7.4. Comparison of Rework Level

The main reason for rework reduction is due to reduction in WIP inventory and balanced work cells. Due to low inventory, mistakes are clearly visible and if any defect is found in the garment, it will be cleared inline, and the piece comes out as a final product. In case of batch processing, until the defect is noticed operators may have piled up bunch of WIP and it is very difficult to clear defective parts. In some cases, there may be new style running in the next section before finding defects. This is the most difficult work for clearing defective parts.

6.7.5. operator Skill Improvement

Mostly the company enhance the operator to operate more than one activity but in the current production processing, due to sitting operation one operator works in one operation only for long time. There is rare chance for operators to do multiple jobs; they do multiple jobs only in critical situations so they don't have much knowledge of another job. They may work more efficiently on the job they were trained but have lack of knowledge for other jobs in the same production line, even make to operate another activity the efficiency is low and makes the line to make waiting or delays. Whereas in case of cellular manufacturing all operators should have to learn at least three to four operations to balance the cell. This is achieved by rotating operators in between machines for the smooth flow of pieces. In previous batch production, there were only a few operators who know multiple operations, so when the critical operators were absent total output was affected drastically, whereas in case of cellular layout the output will remain consistent irrespective of these factors.

6.7.6. Operator Motivation

In most garment the operation activities are not uniform some activity take long time the other activity takes short time, but if all operators are working in multiple operations in rotation. So there is no arguing that someone is doing a difficult operation and others are working in easier operations. On the other hand, this is not possible in batch production because of specific allocated work for the whole day. Similarly, in case of new layout, operators are treated as a group inside

the cell so their combined effort is to do better and produce more. Likewise, operators cannot work carelessly because they will be immediately caught by the next operator inside the cell, so the combined result of all these factors motivates them to do better in each step.

6.7.7. Comparison of cost and revenue

All research activities should have evaluated according to the cost of production and the income generated by the activity, the case product was ordered by customer with sewing service of 0.75 dollar/pieces, the case line has 45 workers with helper 8, train operator 3, line leader 1, maintenance 1, quality control 1, operator 31, the average 26 working day salary and benefit is 1549.43 br. The cost of production only by considering the operator expense decrease by 9296.58 birr per month this is due to manpower reduction regarding the incomes the company case line produces maximum production is improves by 303 units this generates 227.25dollar per day, with 27.52 currency rate the daily income increase 6,253.92br per day, this income is generated due applying lean tools and techniques on production.

6.8. OUTCOMES OF THE STUDY

The research was applied type research that have direct positive impact on lean process through different tools and technique to demonstrate the variables on productivity improvements. The following table indicate the result analysis of current and proposed future state of the analysis

TABLE 24: OUTCOME OF RESEARCH

VARIABLES	CURRENT STATE	FUTURE STATE	PERCENTAGE
WIP inventory	3765	998	73.5
PROCESS EFFICIENCY	6.73	20.75	14.02
CYCLE TIME	76.2	39.74	47.85
LEAD TIME	162959.6	52844.02	67.57
NUMBER OF WORKER IN PROCESS LINE	32	26	20
MAXIMUMPRODUCTION RATE	331	634	47.8

6.9. Research practical validation

The practical validation of the research was done by consulting with company executive manager Mr. J. Ping. Before the implementation practice proceeds, the research report is submitted to company management, after this the implementation proposal is submitted to management body and accepted to implement. After the research gets acceptance, a team is produced to practice. The team members from PPC section, supervisor, line leader, line technician, other train engineers are involved:-

The implementation is permitted to practice on line 10 based on the tendency of problem. To implement all proposed lean tools it needs more time and cost, so that in this research the practice is on appreciable problems, i.e. The defect and rework level reduction is the vivid research concern next to it the absenteeism reduction is secondary concern based on it the practical implementation result evaluated below.

6.9.1. Defect and rework reduction

To reduce the defect and rework level different tools are appreciated in different research but in this research to practice the participative manner and to include all concerned body (supervisor, technician, line leader, mechanics and operators) 5why method is best method and easy to understand with short period. But in research analysis the case product is baby boy shorts but in practical time the case product is already finalized and new order is arrived, in analysis the tools is expected to be practiced in any garment industry so that the practice is done by neat type women trouser in this case product the orders accessories and fabrics is arrived on September 7 Friday 2018 with order quantity of 70,000 after this the sample product is produced in each row and the technician practices the product after this the product is launched to each production line but up to 20/9/2018 there is no finished product is seen. This is due to big defect and rework effect, workers are not well familiar with training, netting type is difficult to sew than fabric type cloths.

The above three causes have their own impacts, fabric type is customer willingness, employee long time training is initial induction and training step causes besides individual natural efficiency to cope up the technical events, the third defect and rework is manageable, but this is imposed by worker training and efficiency. To understand the effect the primary causes are analysed in table below

Table 25 rate of rework and defect

s.no	defect type	21/9/18	22/9/18	24/9/18	25/9/18	total	% of defect
1	pocket high/low	5	50	14	20	89	29.6
2	skipping stitch	0	18	12	30	60	19.9
3	cuff off length un evenness	0	21	26	5	52	17.3
4	puckering	15	7	2	7	31	10.3
5	uneven length (waist)	5	9	0	5	19	6.3
6	cuff/hem	1	0	0	13	14	4.7
7	armhole/knee	10	0	0	0	10	3.3
8	pleated sewing	0	5	3	0	8	2.7
9	stripe not match	2	0	2	3	7	2.3
10	broken stitch	0	3	2	0	5	1.7
11	hem/inseam	0	0	0	4	4	1.3
12	wrong level 1	0	0	2	0	2	0.7

1	pure	38	34	82	84	238	40.55
2	defect	38	126	63	122	349	59.45
3	Total product	76	160	145	206	587	100

From above table the data is gathered shows that the concern is on top defect types that is on skip stitch problem and pocket high low and unevenness problem. If the company eliminate basic problem the company defect and rework minimizes by 66.8% .from the part the waist band, pocket and cuff tight parts are more exposed to defects other parts are minor and tolerable defects,

After analyses serious problem the implementation of lean tools is applied over the main defect so that some improvement are applied over company expert and researchers.

The company practice some mechanical modify on machines to seam straight way on waist band and cuff tight problem, some problems are shown below fig34.

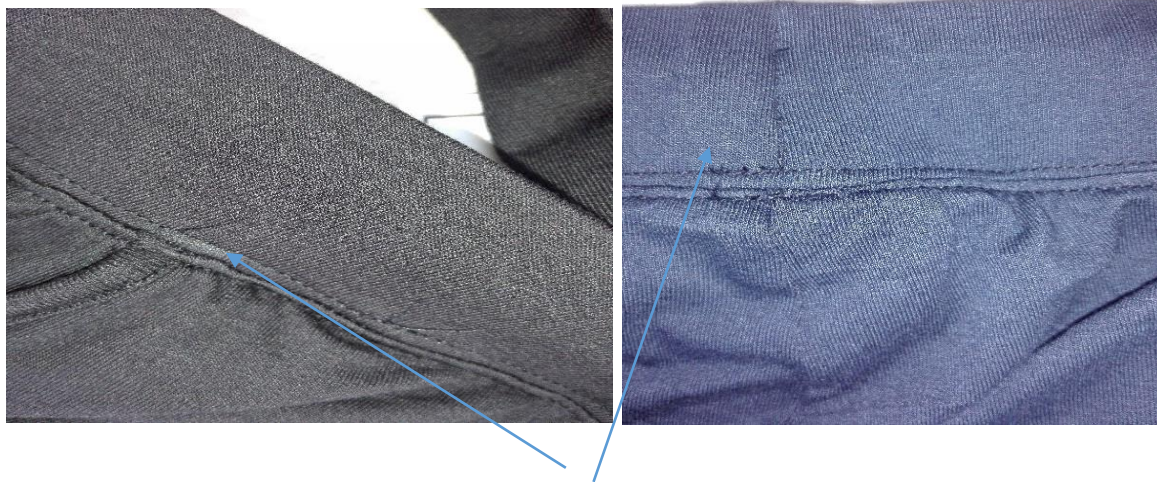


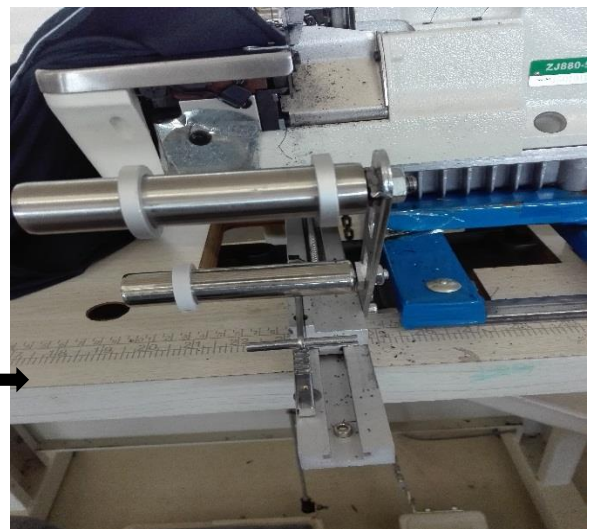
Figure 33 some waist band defects

The company try to eliminate the causes by considering the cause is by cloth type so in order to make straight stitch since the cloth is neat type it stretches and thin density and high stretch type so technically needs to stretch with elastic cord maximum by modify shown fig35 below

The limitation on this modify is

- The parts are taken from can shay machine, but the number of machine is limited
- The modify activity takes long time to proceed in each line
- Oil system have no guarantee from being drop on fabrics.

Based on this the modify machines made is only two in number but their function is well relative to before it generated (machine modify).



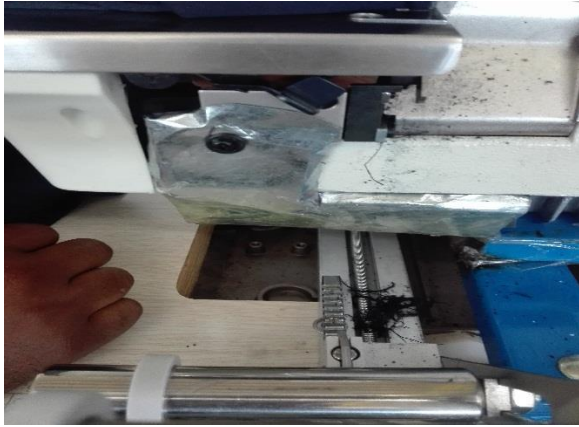


Figure 34 Actual and modified machine

Basically all machines can stitch all types of fabrics so the causes generate by other factors before machine modify the root causes of the main problem should analysis by 5why method and their solution is sets by consequence problems cause.

Table 26: 5why root cause analysis

Effect	First why	Second why	Third why	Fourth why	Fifth why
Pocket high /low	Non straight down stitching on waist band	Cloth stretchiness			
		Insufficient Person performance	Traditional Work procedure	No control mechanism of operation	No mechanism to identify the operators efficiency
Skip & un even stitch	Poor feed fabrics	Unskilled operator			
	Machine problem	Unsuitable thread			
		Defected needle			
		If needle thread loop size is too small			
		Gauging	Improper pad placement	No technical observation	Less technical Focus on operation

As observed from practical 5why analysis the practical action to eliminate is carried out by the action to identify the process, operator and machines based on 5why root cause analysis,

Table 27 solution and root causes

PROBLEM	POCKET HIGH /LOW	UN EVEN STITCH AND SKIP STITCH
Defect part	pocket	Waist band, cuff tight
		Cuff tight
Operator name	Ababo, Lamrot	Tadesse, Tsigie
Machine type	Over lock	Flat lock
Problem sources	Procedure or work flow cause	Machine problem
Specific problem causes	Un even attachment of lower part and waist band on over lock machine	Machine gauge gap, thread tension
Specific of specific causes	Un even attachment of lower part and waist band	Machine gauge gap, thread tension
Focus point	operator	machine
Who take responsibility	Line leader & supervisor	Mechanics
Recommended solution	The operator should write names over part they stitch to identify source of defects.	Proper gauge of the machine, needle and thread tension Attach the fabric on hinge place and some parts on waist band
Goal of solution	To identify individual worker rework level	To limit stitch skip and causes of un evenness

The implementation of the visual control through the 5why analysis to identify the root causes



One of gauging focus point to make left and right stitch width balance it is made from plaster

Figure 35 Gauging zone



Join the partition part

Figure 36 join part at four location

From practical orientation on line 10 the operation takes long time to change from defect problem but when production start the supervisor and line leaders starts to identify the problem, sources, causes and particular solutions to the defect so that the result shows gradual improvement are observed as shown table below36.

Table 27:- Defect and rework type after implement

s.no	defect type	28/9	29/9	1/10	2/10	3/10	4/10	total	%ge
1	cuff off un even and skip	0	0	26	12	11	5	54	16.46
2	skipping stitch	18	0	12	0	10	11	51	15.55
3	pocket high/low	3	3	14	0	11	12	43	13.11
4	stripe not match	3	3	2	7	5	10	30	9.15
5	pleated sewing	0	5	3	12	0	6	26	7.93
6	broken stitch	0	12	2	12	0	0	26	7.93
7	waist	0	10	0	0	0	10	20	6.10
8	puckering	5	7	2	0	0	5	19	5.79
9	wrong size	10	0	0	5	0	0	15	4.57
10	excessive thread end	10	0	0	0	0	2	12	3.66
11	wrong level 1	0	0	2	0	4	0	6	1.83
12	hem/inseam	0	3	0	0	0	0	3	0.91
13	drop needle	0	3	0	0	0	0	3	0.91

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1	non defect product	57	74	82	87	225	178	703	69.5
2	defect product	49	46	63	48	41	61	308	30.5
1+2	final product	106	120	145	135	266	239	1011	100

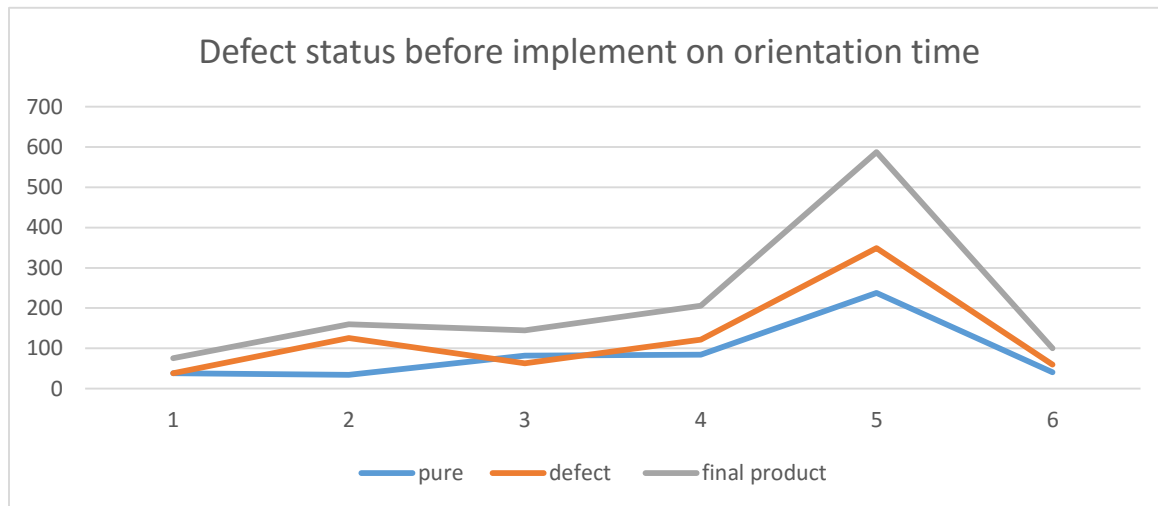


Figure 57 defects before 5 why implement

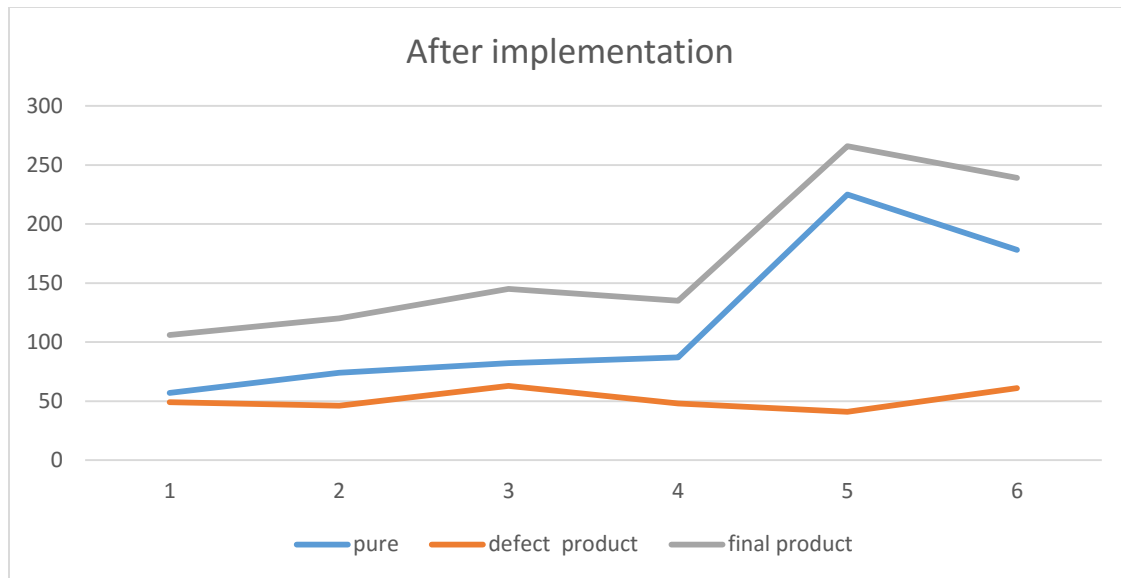


Figure 68 defects after 5 why implement

As observe above the three basic defect causes decrease from 66.8% to 45.12%, the average product number by pieces is decrease by 36 pieces in contrary the production improves with in average number of 58 pieces per day.

The company assign to produce 250 pieces target with 0.5 dollar price per unit trousers, the time required to complete unit activity is 1.54 minutes. So that based on this the outcome of the implementation to decrease defect product is summarize below.

Table 28 Implementation outcome

VARIABLES	BEFORE	AFTER	PERCENTAGE
PRODUCTION COST BY DEFECT/DAY/BIRR	1232	728	40.91
CYCLE TIME	2.9	2.5	-13%
AVERAGE DEFECT AMOUNT	88	52	-40.91
PRODUCTION RATE BY PIECE	58	118	50.85
REVENUE GENERATE PER DAY	\$29	\$59	50.85

CHAPTER SEVEN

7. CONCLUSIONS, RECOMMENDATIONS AND FUTURE RESEARCH DIRECTION

7.1. CONCLUSION

This research study was carried out in case company that manufactures garment products, in research the lean manufacturing tools and techniques were applied in addition the eighth waste analysis was included, from lean tools elimination of waste was the concern area, having complete company production analysis final solutions and recommended procedures were set as a solution, to achieve this conclusion some crucial lean tools were like 5s, line balance, VSM, 5why were applied.

From the findings of the study it can be concluded that:

- The application of 5s was to clear unorganized work area especially on cutting section to make easily movement but the wide application should include other sections, plus the programmer should need periodical Audit in formal structure.
- Due to a lack of performance indicators for individual operator efficiency or production line efficiency, a general control format was developed to control individual productivity.
- The eighth waste type should need subjective periodical assessment and deep screening of employees besides it individual efficiency regarding on productivity and production control trends must modified every time.
- In output analyzing results and comparing them with previous data, it was noted that, when implementing the tools and techniques, the company will show, improving productivity and profitability,

Finally, even though the conclusions derived from this study are specific for the organization in the study, it may be replicated in same other manufacturing companies with some changes in the manufacturing system selection criteria that are relative to its strategic objectives.

7.2. RECOMMENDATION

In view of the findings and conclusions of the study the following recommendations will forwarded to the managements C&H garment:

- In order to improve the productivity of the factory the company should focus on manpower effectiveness; besides it the production management should practice and implement lean manufacturing system.
- The company training policy modify, it should be done deeply technically and discipline ways performance of the organization and attain a better competitive position than their competitors.
- The lean implementation should be done first at top level commitment and well training should be takes place besides it extends to all company members and work areas.
- The company should develop IE (industrial engineering) section that monitor production planning and control and training sections.

Furthermore, for the successful implementation of lean manufacturing tools and techniques to sustain the benefits obtained from the lean practice, the following recommendations are forwarded to the case organization:

- Unnecessary inventory and defect products and reworks should be the primary concern because of the analysis result indicate WIP inventory and defects take the major waste type in garment.
- The company setup time from one product to other should be in smooth way.
- The top management should have an initiation, responsible, and committed to the lean manufacturing implementation program;
- Lean expert consultant must be involved and lead the pilot project;
- All the employees of C&H should undergo the lean training and get involved in the lean practice;
- Lean culture and teamwork should have to be developed in the company to sustain the lean practice;
- The proposed framework must be followed accordingly and each step has to be practiced properly to achieve the objectives without any interruption.

In addition to lean manufacturing system, the managements of C&H should give a concern on worker turn over and absenteeism's so in order to minimize this trend the company can deal with government and build workers house and rent with minimum value to balance the turnover rate by minimization of work life balance effects.

7.3. FUTURE RESEARCH DIRECTION

The lean manufacturing system philosophy has more number of tools and techniques to improve the company productivity to make a number of decision in productivity improvement the company should have strategic concern to get the positive advantage of the philosophy.

The main future research direction on lean application and practices are: -

- How lean application can integrate the company strategy planning with daily manufacturing activities.
- The implementation framework of lean should support with modeling to validate the actual existence and trends.
- The lean application in service activities of the company like supply chain and store management need further study since it has impact on productivity.
- The waste of lean have dependency impact one waste of lean have direct and indirect impact over the other so its impact should be further analyze.

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APPENDIX A: REVIEWED JOURNALS

sn o	Title	Problem	Methodology	Result	Tools used	Research gap	publisher
1	Enhancement in productivity in sheet metal industry through Lean Principles Gaurav Kumar* , Rajender Kumar** and S.K. Gupta	challenge for improvement in the productivity of the plant, large inventory and WIP, the motivations morale of the employees is very poor	Analysis of Current situation of the process, Standard time calculations, Calculation of capacity for each station,	a company has got a capacity to produce 110-120 parts per day. But as per chart, there are 3 processes which are below line of 110 Nos. It means, in these 3 processes which are needed to be improved so that productivity can be improved to be remain in competitive market.	work study methods	large inventory and WIP is related with worker capacity but the worker motivation is only focused on work study bottle neck identification side	International Journal on Emerging Technologies 4(1): 186-191(2013) ISSN No. (Print): 0975-8364 ISSN No. (Online): 2249-3255 india
2	STUDY AND ANALYSIS OF THE SCOPE OF VALUE STREAM MAPPING (VSM) TECHNIQUE APPLICATION IN A SELECTED GARMENTS FACTORY OF BANGLADESH K. M. Mostafizur Rahman Sobuj, 2Chowdury M L Rahman,	breakdown losses, quality loss, small stops, startup rejects to improve the effectiveness of the production line	Quantitative data were analyzed by using tables and graphs from analysing current status of VSm, waste identification, pareto and cause and effect analysis, finally production problem identification and improvement will be carried out	Waiting Time, defects, transport and excess motion are main problems identified but the research results Value added activity has been increased from 0.62% - 1.1% · Waiting time has been reduced from 283.58 min. to 115.26 min. · Productivity has been increased	Pareto analysis, Cause-effect analyses, Five S (5S) and 5 Why analysis; are used to find existing situation and to identify various types of wastes exists in the selected industry	VSM is the only focus area the other lean tools are not well addressed	International Journal of Engineering Research and General Science Volume 3, Issue 2, March-April, 2015 ISSN 2091-2730 BANGLADESH

				· Lead time has been decreased · Bottleneck point has been reduced.			
3	MINIMIZING THE EIGHTH WASTE OF LEAN- ABSENTEEISM THROUGH SIX SIGMA METHODOLOGY C.S.Chethan Kumar1) NVR Naidu1)	there is an increase in employee absenteeism	six sigma (DMAIC) method	percentage rate of absenteeism decreases	fish bone diagram,pareto (statistical data analysis)	The improvement method contain worker legal accessible things (salary,gloves etc) but in training machine protective is primary operator trainning not for absenteeism,other problem like harasment problem isnot adressed well.	International Journal for Quality research UDK - 677:658.562(540) Short Scientific Paper (1.03) India
4	Implementation of Lean Manufacturing Tools in Garment Industry T Saravana Kumar, PR Soumya, V Minu Manjari, RE Aishvariya, N Akalya	due to lower skill levels and traditional manufacturing systems, the garment industries are able to achieve 50% to 60% productivity level (The company has been facing	primarily identify bottle neck and solve it through vsm and make line balancing,reduce cycle time	The bottleneck areas were eliminated by implementing line balancing and parallel working section The implementation of kaizen resulted in reduction of cycle time by 48.7%.The value added percentage got increased from	VSM,kaizen,	it only improves the process but doesnot improve productivity.	International Journal of Latest Technology in Engineering, Management & Applied Science (IJLTEMAS) Volume VI, Issue III, March 2017 ISSN 2278-2540 India

		problem with unbalanced productivity among various operations in sewing department.)		0.397% to 0.431% which accounts for 8.5% improvement in the processes.			
5	Using Lean Manufacturing Techniques to Improve Production Efficiency in the Ready Wear Industry and a Case Study Vedat Dal,*Engin Akçagün,*Abdurrahim Yilmaz	to increase efficiency and working activity by using lean manufacturing techniques in the production line	Revealing current and future state via value flow chart ,Analysis of product tree of present models , Analysis of the process time of each model group , Analysis of the production labour plan and layout plan	29% increase in efficiency is achieved	Lean manufacturing techniques and especially that of value flow analysis are used to acquire data in this study. Moreover REFA work and time study techniques were used in determining process times of shirt models.	this case is observe most lean tool application but human base improvement is not adressed	Marmara University, Faculty of Technology, Department of Textile Engineering Turkey
6	IMPACTS OF LEAN TOOLS AND TECHNIQUES FOR IMPROVING MANUFACTURING PERFORMANCE IN GARMENT MANUFACTURING SCENARIO: A CASE STUDY G. Vijayakumar, Y. Robinson	identifications of significant problems related to lean waste occurs in garments	the implementation of DMAIC and cause and effective diagram are used for eliminating garment defectives and 5S Concepts for reducing defects and motion	The garment worker will feel more comfortable at work and the continuous improvement actions will tends to minimum waste and good quality of items, which improves the firm's competitiveness and profitability.	5S, cause and effect, pareto,	wastes are not identified from lean tool it takes from literature	Vijayakumar et al., International Journal of Advanced Engineering Technology E-ISSN 0976-3945 Int J AdvEngg Tech/Vol. VII/Issue II/April-June, 2016/251-260 Research Paper
7	Application of Lean Manufacturing Tools in a Garment Industry as a Strategy for Productivity	the company does not have a standard operation time.	The descriptive research design was used by the researcher to gather information about	manpower requirement, WIP decreases and efficiency increases	Just in Time ,work study Process Flow	less population size on research	Asia Pacific Journal of Multidisciplinary Research Vol. 3 No. 4, 46-53 November 2015 Part V P-ISSN

	Improvement Rebecca M. Nunesca and Aile T. Amorado	Similarly, the researcher observed non-value activities such as unnecessary transportation and manual counting, and there were also product defects due to poor 5S and WIP inventories.	present existing conditions a combination of Qualitative and Quantitative Research were used to gather relevant data on current status self constructed interview guide, standardized forms such as Cycle Time Observation Form, Process Flow Chart, and 5"S Audit Checklist were the main instrument for data collection.	minimize waste, enhance quality of products and definitely create its sustainability			2350-7756 E-ISSN 2350-8442 www.apjmr.com Philippines
8	A Study to Reduce the Lead Time of a Bakery Factory by Using Lean Tools: A Case Study Md. Monir Hossain	long lead time	the data is collected through observation and lean tools Pareto principles were used to find out, quantified and also to reduce the causes prior to short lead time. Takt time and PCE considered as the process capability factors	after the implementation of lean tools at future state, the lead time, PCE and Takt time would be consecutively improved	VSM, PCE and Pareto analysis were used	it focus on lead time minimization doesnot consider waste reduction methods.	International Journal of Scientific and Research Publications, Volume 5, Issue 11, November 2015 ISSN 2250-3153 BANGLADESH
9	HEIJUNKA TECHNIQUE FROM LEAN PRODUCTION TOOLS AND ITS APPAREL APPLICATIONS Meral İşler, Mücella Güner	a production in comply with changing demand conditions, and a balance for the production	Heijunka	formulate well structured order in cutting section	simple visual analysis along with heijunka	the research focus on scheduling doesnot include productivity improvement	XIIIth International Izmir Textile and Apparel Symposium April 2-5, 2014 turkey

		process in the philosophy of lean manufacturing				of worker by this methods.	
10	Waste Reduction and Productivity Improvement through Lean Tools Masudul Haque Talukder1, Mohammad Ali Afzal1, MD.Abdur Rahim, Mohd.Rifat Khan	identifying and reducing of wastes and improving productivity	collect and analyze data by direct observation. Wastes are identified by using value stream mapping	workforce is reduced ,Required space is reduced , Over transportation is reduced ,Inventory is reduced,. WIP is reduced ,Lead time is reduced , Efficiency is improved ,Labor productivity is improved in both A and B cases,	Vsm, Cellular Manufacturing, cause and effect diagram, Kanban pareto & bar graph 5why are used in sewing, cut-ting and finishing section	Major wastes in both case A&B are not identified in tangible ways	International Journal of Scientific & Engineering Research, Volume 4, Issue 11, November-2013 ISSN 2229-5518
11	Productivity improvement through lean manufacturing tools (A case study on Ethiopian Garment industry) Daniel arefayne&Ajit Pal Singh	longer production lead time,high rework,poor line balance,lack of standard on work process and performance measurement system for the employee,high work-in-process,low production capacity,high labor (operator) absenteeism,high rework,high	Quantitative research methods and different lean manufacturing tools(standardization of work process,line balancing,5s) time study standard allowable minute (SAM)	after line balance the number of worker to produce equal amount of garment reduced,productivity of machine increase, 5s improves 41sqmeter area	lean tool (kaizen,kanban,poke yoka,takt time/cycle time,cell layout,5s,VSM,,Total productivity maintenance,multifunction employees,uniform work load,employee involvement,TQM, Training,Team work,production smoothing,work standardization,visual management,Ishikawa diagram,JIT,visual displays and control,operational planning and six sigma)	no setted worker productivity it focus on statistical analysis of lean tools	IJERT VOLUME 3 ISSUE 9, SEPTEMBER 2014 Ethiopia

		fabric waste and poor resource utilization are among others.					
12	Improve the Productivity with help of Industrial Engineering Techniques Pranjali Chandurkar, Madhuri Kakde, Abhishek Bhadane	intensified by global competition	IE techniques	reduced operation time , increase operation efficiency	method engineering, work study, capacity study, line plan	the research focus on standardaize the operation and work study is applied over the process the main intial base is to create customer drive industry , the productivity improvement is not adressed well.	International Journal on Textile Engineering and Processes, ISSN: 2395-3578 vol 1, issue 4, oct 2015
13	Productivity Improvement by Lean Manufacturing an Automobile Industry with the Help of Method Study Jitendra Mandloi & Mr. Abhishek Yadav	ASSEMBLY design LINE balance problem	the methodology follows astep of select,record,compa ny analysis,critical examination,	the project is to make effective increase to productivity, which will help in assessment of leanness of the company	method study	ideal theoretical plan that helps for future assembly line design	Global Journal of Researches in Engineering: GIndustrial Engineering Volume 14 Issue 4 Version 1.0 Year 2014 USA
14	A shop_ floor kaizen breakthrough approach to improve working environment and productivity of a sewing floor in RMG industry Md Abdul Quddus AMM Nazmul Ahsan	WIP and waste	the methodology is follows training,data collection,5s Audit,take action and maintenance procedure finally visualization	the efficiency increase the WIP decreases	the research uses kaizen break through (SKB) approach supported with bar chart,fish bone diagram,& mathmatical model	The research carried out as aproject for five day it may not have sustainable application	Journal of textile and apparel, technology and management Volume 8,Issue 4, spring 2014. Bangladesh
15	A PROPOSAL TO IMPROVE	lack of willingness to	questionaries design, surveying,	lacking Indoor area for painting	employee engagement conceptual frame	the engagement	THE INDONESIAN

	EMPLOYEE PERFORMANCE THROUGH EMPLOYEE ENGAGEMENT SURVEY IN PT KBI Albertus Harvid and Aurik Gustomo	train, lack of employee development program, and lack of facilities.	Analyzing the survey data, multiple linear egression, joint problem diagnosis and action planning	and wielding, and the storage capacity,the employee think training is wasting time	work ASTD, DDI and Gallup spss,	system focus on worker performance efficiency that has direct impact on productivity of acompany the reserrch adress main problem of the worker	JOURNAL OF BUSINESS ADMINISTRATIO N Vol. 2, No. 1, 2013:17-28 Indonessia
16	Embracing Manpower for Productivity in Apparel Industry S. Shanmugasundaram and N. Panchanatham	diagnosing factors of labour productivity in the Apparel Manufacturin g	research. Journals, reports, books, trade publications, articles, research papers and the records of Apparel Export promotion council, and Handloom Exports Association,	Absenteeism was the main chronic problem that affected productivity in majority of the units. Labour turn-over and socio-economic background of the employees also affected labour productivity.	Ranking of factors , statistical tools	it focus on worker personal motive to increase productivity does not integrated with other management approach	International Journal of Innovation, Management and Technology, Vol. 2, No. 3, June 2011 India
17	APPLICATION OF LEAN CONSTRUCTION TOOL (L.P.S) TO IMPROVE LABOUR PRODUCTIVITY AT CONSTRUCTION SITE Anshi Verma*1, Dr. S.S. Angalekar2, Prof. Manish Khandare3	poor management in resources, waste management, over budgeting and schedule lagging	Collection of references include journals, technical reports and books,Data collection from observation and questioner survey and lowest possible level in a whole range of one-off production calculation to find out labor productivity at construction site.	Transparency in scheduling Avoid waste of resources, Proper monitoring and improve labor productivity , Easy to planning the next activity, Efficient use of time, Less dispute due to clear vision / planning	BIM (Lean Design), A3, process design (Lean Design), Offsite fabrication and JIT (Lean Supply), Value chain mapping / Last planner system (Lean Assembly), Visual site (Lean Assembly); 5S (Lean Assembly),	the research is done in project way for improving proming date by maging clear vision on planning	INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY Verma* et al., 6(6): June, 2017 India

18	The Use of Productivity Improvement Tools and Techniques in the Botswana Textile Industry H. Mapfaira, M. Mutingi, V.P. Kommula, K. Mashaba, M. Malema, and T. Selema	Failure to be competitive is due to poor quality of local textile products as well as high production cost as a result of poor operational efficiencies characterising the country's textile industry	descriptive survey method comprising qualitative data gathering through interviews and quantitative data gathering through survey questionnaires.	The research has indicated a high implementation failure rate, most textile companies lacking knowledge and understanding on the application of productivity improvement tools, magnified the consequences of poor implementation and inappropriate selection of productivity improvement tools, as well as poor selection of productivity improvement projects.	productivity improvement tools and methodologies (PITs), Bar chart Graph, arithmetic analysis in addition 56 different lean and management tools are used as comparison	it how the country total scope of practicing productivity tools not specific company progress	International Journal of Mining, Metallurgy & Mechanical Engineering (IJMMME) Volume 3, Issue 3 (2015) ISSN 2320-4060 Botswana
19	19	An Investigation of Lean Manufacturing Implementation in Textile Industries of Pakistan Zahid Abbass Shah and Hadia Hussain	Lack of awareness to implement lean, company culture, lack of communication, and employee resistance	data collected through grouping the industries with questionnaires and analysis the barriers of a company on implementation of lean	cost reduction to be the biggest benefit that can be achieved by implementing lean, followed by customer satisfaction, and improved delivery time	5S, quality control circles, kaizen and SMED	The research focus on country wide implementation not on specific industry
20	20	Application of Lean Manufacturing Tools in	as high WIP results in increasing the throughput time and as well as the	Analyse of current VSM, understand the customer requirement,	More than 80% Work in Process inventory reduction as the new work cell will be	VSM, cellular manufacturing, *- single piece	It clarifies only lean tool application and focus on cellular manufacturing

		Garment Industry Rashmi Kumari1, T. Z. Quazi2, Rishi Kumar	flexibility of manufacturing firm can also be increased in order to meet customer changing need and demand.	recognize supplier capabilities and constraints. After that the current WIP is calculate, finally new VSM is developed & cellular manufacturing is proposed	arranged, Flexibility will be improved by Cellular manufacturing, The number of operation required to complete the work will be reduced, Number of operator or labor will be reduces as there will be no need of quality check	flow, work standardization, 5S	
21	21	Implementing of Lean Tool in Garment Industry: A Review M.Sugadeva Boopathi1, S.Sendhil kumar2	low productivity, longer production lead time, high rework and rejection, poor line balancing, low flexibility of style changeover	Lean principles and tools like VSM, 5S, Kaizen, TPM, poka-yoke mechanisms or others, are used to achieve this trend by diagnosing, measuring, improving and supporting the sustainability of production systems	production cycle time decreased by 8%, number of operators required to produce equal amount of garment is decreased by 14%, rework level reduced by 80%, production lead time comes down to one hour from two days, work in progress inventory stays at a maximum of 100 pieces from around 500 to 1500 pieces	cellular manufacturing , single piece flow, work standardization, just in time production	the journal does not show which lean tools are show the improvement

