Productivity Improvement through the integration of lean and work study

(Case in Addis Ababa Garment sc.co (Augusta) Addis Ababa)

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This is to certify that the thesis prepared by Hiwot H/Mariam, entitled: Productivity Improvement through the Integration of Lean and Work Study and submitted in partial fulfillments of the requirements for the degree of Master of Science (Mechanical and Industrial Engineering) complies with the regulations of the University and meets the accepted standards with respect to originality and quality.

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Declaration

I hereby declare that the work which is being presented in this thesis entitled "Productivity Improvement through the Integration of Lean and Work Study." is original work of my own and has not been presented for a degree of any other university and all the resources of references used for the thesis have been duly acknowledged.

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Dr. Kassu Jilcha Date

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ABSTRACT

Productivity improvement is an everlasting continuous activity in manufacturing. Industries need to develop capability of coping up with customer demands to deliver quality products on time. Continuous improvement is the need of the hours which can be achieved by incorporating flexibility in layout, design and processes. This paper is aimed at improving productivity of garment manufacturing industry through the integration of lean and work study approaches. The work measurement of various elements of the work cycle has been made on the basis of picking, sewing and disposing of one operation to the next operation. The work cycles were divided into small measurable work elements. These elements were recorded on the observation sheet. Observations have been recorded for different trails to analyze the operations effectively for identification of value-added and non-value added element and lots of calculations and other mathematical methods. The lean and work study integration by schematic model to answer the research questions and to improve the productivity of the company.

Keywords: Productivity, work measurement, standard time, waste, time study, work study, lean

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LIST OF ACRONYMS

CI------- Continues improvement

GTP------Growth and transformation

JIT------Just in time

SKU------Stock keeping unit

SMDE------Single minute die exchange

SMV------ Standard minute

TIDI ------Textile industry development institute

TPM------Total productive maintenance

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

Today's textile and garment manufacturing become a good industry. That turns out a wide variety of products to meet customer demand. It is especially in the apparel industry that managers are trying to develop their current systems or looking for new production techniques in order to keep pace with the rapid changes in the Fashion industry (Mucella G.Guner, 2003).

Currently, over the world textile and garment is one of the biggest consumer goods categories with a global market estimated to be worth well over one million Euros. Nowadays, the global competitions in textile and garment products become very intensive. In general, it is possible to observe the situations of textile and garment competitions in three categories. Textile and garment manufacturing in developed, developing and under developing countries (Mahmud F. N., 2015).

The fashion industry is highly volatile if the orders are not fulfilled on time, the fear of losing business is real (Mahmood, 2015). Today, industries are getting the same or more volumes (orders), but the number of styles they have to handle has increased radically. Earlier industries were getting the bulk order so there is no need to worry, if the production line was set for the first time it would run for a month or at least a week or two (Matebu, 2002). This limitation of existing techniques forces researchers to find a more comprehensive improvement technique to improve the productivity of a company. One approach of this is the use of the integrated approach to form a comprehensive and reliable set of manufacturing practices and their synergy supportive and contributes optimistically to continuous productivity improvement (Tesfaye, 2016).

Lean focuses on identifying ways to streamline processes and reduce waste (Rothenberg, 2016). The application of improvement tools and techniques, such as lean manufacturing and work study contribute significant improvement effort to solve productivity problem of

Ethiopian textile and garment industries. This is because Lean focuses on eliminating the sources of waste (Importa, 2015) aiming a continuous process flow while; work study carrying out different yet related activities. Various business management strategies have been developed to improve the performance of organizations by improving the processes by which they carry out their work. These strategies include lean and work study, aim to implement process improvements through a coordinated set of principles and practices that promote greater efficiency, effectiveness and productivity with fewer wasteful practices or errors. Lean is efficiency and reduces waste (Mason, 2015).

Lean has been gradually more acceptance in the textile and other industries, which faces many of the same issues and challenges--how to reduce waiting time, how to increase capacity, how to be best organize resources, etc. (Kuo, 2010). Where the strength of Lean lies in providing a set of proven techniques for eliminating waste and Work Study technique principles have the ability to empower the workers, motivating them with effective and efficient processes. Integrated Model for Continuous Productivity Improvement in textile and garment industry.

Work study carrying out different yet related activities such as to improve the efficient use of resources and to set up standards of performance for the activities to be carried out and lean can help the company to move ahead in the market competition by increasing production by waste elimination, well-being and safety of workers. Most researchers have done on integrated lean with six sigma or lean with total quality management Welder (2007). Integrated lean with ergonomics by taking ergonomic problems try to give solve by lean approach although both methodologies are focused on process and quality improvement (Antony, 2010). Lean is formalization and codification of experience and judgment which is not a feature of Six Sigma. Lean emphasizes speed and waste (Douglas, 2009) (Antony, 2010).

Justification of the Study;- The study focuses on identification of barriers to improve productivity and develop continuous productivity improvement model for Ethiopian garment industries by taking Addis garment Sc. Co (Augusta) as a case company.

This research proposes the synergistic combination of work study and Lean for productivity improvement.

1.2 Problem Statement

Textile and garment producing firms in Ethiopia have been involving in the international markets long years ago but until the exports were not sufficient according to the numbers of companies that established in the country. Only a few firms are able to reach the highest stage of the value chain, produce and export finished garments **(Matebu, 2002)**.The factory lacks competitiveness both in locally and internationally due to lack of quality and production volume of finished garments required by the customers. Limited technological capabilities, lack of modern processing equipment, poor market system and these will lead to poor productivity of the textile industry **(Mahmud F. N., 2015)**. Ethiopia's Textile Industry Development Institute (TIDI) has predicted $ one billion in yearly revenue from textile and garment export during the second phase of the growth and transformation plan (GTPII). Under the Growth and Transformation Plan (GTP), the Ethiopian Government has targeted to achieve $1 billion in exports of textiles and apparel during 2010-11 to 2014-15 period. But, the performance of the Ethiopian textile and clothing exports during the first three years of GTP period was only $305 million, much below the $637 million envisaged during the period under the GTP.

In 2012-13, Ethiopian textile and clothing exports fetched US$ 99 million, which was much lower than the Government target of US$ 357 million for the financial year. Even if there are over 100 companies operating in the Ethiopian textile and clothing sector, during the nine-month period of 2013-14, only 16 companies together accounted for more than 80 percent share in export of textiles and apparel, according to textile industry development institute (TIDI). In the first quarter of 2014, the figure was earmarked at USD 29 million. To solve the above problem the factory use disorganized and reactive problem solving approach which is not effective for improving productivity in a continuous manner. The main reasons for not

using organized and continuous productivity improvement program are lack of understanding and commitment from top management As (Matebu, 2002).some other Ethiopian manufacturing firms‟ those implemented Kaizen philosophy; Most organizations start improvement notion to come up with a solution to their problems but, they ignores continuous improvement effort Some of the problems associated with Ethiopian garment industries are lack of knowledge about the marketplace and their competitors, unsuccessful process and product innovation schemes, ineffective production planning and controlling systems, absence of coordination between suppliers, customers and industries, absence of quality concepts and modern management practices, and ineffective financial and human resource management's (Mucella G.Guner, 1973).

According to the TIDI plan, Addis garment sc.co must produce 6000 up to 10000/pcs per day but the current production is 1000 -1200/pcs per day it's less than the planned. It means they produce 16.66%/ day.

Therefore, by implementing the integrating work study and lean approaches to this factory will be solve their problems and will make them competitive in the market in line with their improvement of productivity performance because the new continuous improvement methods improve the factory main problems.

Research Questions

1. What are the hindering factors that affect the productivity of the Addis Garment (Augusta) sc.co?
2. What is the relationship among work study and lean for productivity improvement?
3. What are the intervention areas for the shirt production improvement?
4. What kind of productivity improvement model can be used to improve the problem?

1.3 Objectives

1.3.1 General Objective

The general objective of the study is to enhance productivity through integration of work study and lean approach tools at Addis Garment sc.co (Augusta) Addis Ababa.

1.3.2 Specific Objectives

- ✓ Identify the factors those affect the productivity of the factory and their indicator.
- ✓ Identify the common relationships among work study and lean for the productivity improvement.
- ✓ Identify the intervention area for continuous productivity improvement.
- ✓ Develop model for continuous productivity improvement.

1.4 Significance of the Study

The study outcome benefits for Addis Garment sc.co as well as other garments firms through the adoption of continuous productivity improvement technique that helps to improve the status of productivity factors available in the factory. Moreover the improvement techniques bring tangible changes in the production process of garments and general working conditions in Ethiopia. It will provide an integrated approach which is helpful to improve flexibility and efficiency of the production process the company policymakers can make them production policies depend on this. Also, other researchers can read and they can modify it.

1.5 Scope of the Study

The scope of this project is to assess first the Ethiopian textile and garment industry as a whole by referring different secondary documents and visiting partially those that are located in Addis Ababa city to understand generally where are most challenges that faces by the industries under this subsectors arises. Then after, in this research see the industries like Almeda textile p.l.c, MAA Garment industry p.l.c because they are using partially the lean principles and Addis Garment sc.co Addis Ababa conducted to assess first in detail the existing situation of the company according to the title, then to identify the core problems that are confronts for these company production departments, the study concentrates only on model development for the continuous productivity improvement by the integration of work study and lean approach. But Due to time and another resource shortfall couldn't go further in the implementation (practical work).

1.6 Limitation of the Study

It was hard to convince the respondents about the aim of the study. It's the limitation during the survey and data collection phase.

1.7 Organization of the study

The paper is organized in seven chapters. The preceding chapter is an introductory part, which contains the problems, objectives, scope, and limitation of the study. Chapter two the literature review part on how to integrate, work study, time study, lean tools, wastes definition benefits highlights review of studies on production sector and gap of the literature. Chapter three the methodology, sampling strategy, tool and method of data analysis, data source discussed. Chapter four deals with the over view of Ethiopian textile and Garment sub sector and the company background. Chapter five contains the data collection and analysis, result and discussion in detail. Chapter six deals the proposed continuous productivity improvement model, model development criteria and detail of the proposed model .Finally the conclusion, recommendation and future study area.

CHAPTER TWO

LITRATURE REVIEW

2.1 Introduction

Continuous improvement is a culture of sustained improvements targeted the elimination of wastes. On the Production is the provision of a product to satisfy wants and need the process involves business adding value to their products (Marina Khmara, 2013). Productivity is any process or procedure developed to transfer a set of input into a specified set of output in proper quality and quantity thus achieving the objectives of an industry (Md. Abdul Moktadir1, 2017). Lean describes a system that produces what the customer wants and when they want it with minimum waste. Work study is a method of measure work for recording the times of the stage an assured specific job or its elements carried out under specified condition.

2.2 Global Production Environment

According to Olena Grinenko et.al, (2017) Global production networks are one of the most important factors in the innovative transformation of countries and regions. It is fulfilled due to world production network, being the direct for the transfer of global knowledge and technical know-how to regional structures, regions of the former periphery have quickly become developed, innovative regions with a specialization in the sector of highly qualified services (Raffia N. B., 1989), production of high-tech products, and generation of scientific knowledge. For global companies global production networks diminish their costs and financial risk by sharing with other companies, as well as global division of labor, an important part of global production. Majority of developing countries has begun more actively to take part in GPSs. Share of developing Countries in global trade within GPSs have increased from 20% in 1990 to 30% in 2000 and to more than 40% (Olena Grinenko, 2017). However, many poor developing countries still compete to get access to GPSs in different areas except for exports of natural resources. Regional links between production systems usually have been more significant than international, particularly in North America,

Europe and Eastern and South-Eastern Asia (Raffia N. B., 1989). Regional production systems are relatively less developed in countries with transition economy, Latin America and Africa (World Investment Report, 2014). In the developing countries a share of production within GPSs accounts for almost 30% of GDP in these countries in average against 18% in developed countries. There is also a positive correlation between participation in GPSs and GDP per capital dynamics (Olena Grinenko, 2017).

2.2.1 Productivity

The definitions of productivity depend on the perspective of individual or organization. According to Durdyev, (2011) productivity is an effective utilization of the resources to achieve set objectives or it can be defined as "quantity of output of a process per unit of resource input", which aligns with several approaches.

According to Julian Buenos (2015) productivity is one of the most renowned concepts within the field of business administration. Because of that a lot of the management strategy is planned to attend the factors that affect it. Nevertheless, it could be difficult to identify them all because of the diversity of circumstances they come from. .

2.2.2 Productivity Measurement

Among the fundamental principles of productivity improvement is that the productivity of the existing process should be measured in as much detail as possible before any attempt is made to improve. Productivity is one of the various measures that are used to evaluate the performance of an organization (Sharon A. Schweikhart, 2016) (Ephrem, 2015) Productivity measurement has been practiced by almost all types of establishments regardless of their size and status. Productivity can be measured by**:** ***Total productivity****:* the ratio of total output to the sum of all input factors. ***Partial productivity:*** the ratio of output to one class of input. For example, labor productivity (the ratio of output to labor input), capital productivity (the ratio of output to capital input) and material productivity (the ratio of output to materials input). ***Surrogate Productivity****:* Surrogate productivity indicators are the measure of surrogate factors and they are not measured directly as the ratio of output to input.

2.2.3 Big factors affecting productivity (Mahmood, 2015)

Internal factors: they are included inside the dynamic and the production process of the company but not necessarily belong to it.

External factors: they are physically outside of the company, in the external context but affecting the productivity.

Foreign factors: its not affect the factory production but affect the society

Own factors: they belong to the company and are directly in touch with the external context.

According to Mazharul Islam Kiron (2014) Factors Influencing Productivity in Textile Industry classify into two(A) controllable (internal) factors and (B) un-controllable (external) factors.

(A) Controllable (internal) factors

1. Product factor: the product meets output requirements product is judged by its usefulness.

2. Plant and equipment. The increased accessibility of the plant through proper preservation and reduction of idle time increases the productivity.

3. Technology: Innovative and latest technology improves productivity to a greater extent..

4. Material and energy: using a good quality material and low energy consumption materials will improve the productivity.

5. Human factors: Productivity is basically dependent on human skills such as education, trainingandexperience..

6. Work methods: Improving the ways in which the work is done (methods) improves productivity, work study and industrial engineering techniques and training are the areas which improve the work methods

7. Management style: This affects the organizational design, communication in organization, policy and procedures. A flexible and active management style is a better approach to increase productivity.

B. uncontrollable or (external) factors

1. Structural adjustments: Structural adjustments include both economic and social changes. Economic changes that influence significantly are:

- A Shift in employment from agriculture to manufacturing industry,
- Import of technology, and
- Industrial competitiveness.

2. Natural resources: Manpower, land and raw materials are vital to the productivity improvement.

3. Government and infrastructure: Government policies and program are significant to productivity practices of government agencies, transport and communication power, and fiscal policies (interest rates, taxes) influence productivity to the greater extent Both Mahood (2015) and Mazharul Islam Kiron (2014) try to show the factors affecting productivity Mahood put the factors generally but Mazharul Islam Kiron puts the factors specifically that's the difference but both of them have almost the same ideas.

2.3 Continuous Improvement

Baghel.et. al (2005) defined CI more usually as a culture of sustained improvement target the removal of waste in all systems and processes of an organization. It involves everyone working together to make improvements without necessarily making huge capital investments. CI can occur through evolutionary improvement, in which case improvements are incremental, or through radical changes that take place as a result of an innovative idea or new technology. Often, major improvements take place over time as a result of numerous incremental improvements (Habte, 2013).On any scale improvement is achieved through the use of a number of tools and techniques dedicated to searching for sources of problems, waste, and variation, and finding ways to minimize them. Continuous Improvement should be a mindset throughout your whole organization. Lean Manufacturing is a systematic approach for achieve the shortest likely cycle time by eliminate the process waste through continuous improvement. Thus making the operation very efficient and only consisting of value adding steps from start to finish. In simple words, lean is manufacturing without waste (Antony, 2010).

Need for continuous improvement in contemporary manufacturing scenario (Singh, 2013)

- ✓ satisfy global customers and achieve sustained organizational growth, need to change and remain competitive, need to critically monitor and regulate work-in-process (WIP),to improve organization's work culture and mindset, to get better productivity and high quality ,problems faced by organizations in a form of internal factors like low productivity, high customer complaints, high defect rates, non-adherence to

delivery time, increase in wages and salaries, lack of knowledge, skill of workers and high production system losses and to make the job simpler and safer.

In addition, continuous improvement implementation in an organization can also lead to realization of intangible benefits in the form of improved image of the organization, leading to the possibility of increased orders. Also helps to foster motivation in the workforce, through adequate empowerment, and training.

2.4 Lean

Bhamu and Sangwan (2014) stated that the concept of Lean originated in Japan when manufacturing firms could not afford huge investments in rebuilding their industries. Toyota was the first automobile company to adopt Lean manufacturing and produced a variety of cars at the lowest possible cost while keeping the smallest possible inventories. Lean manufacturing was propagated by Womack *et al*. in their book the machine that changed the world. Lean aims at reducing cost by eliminating waste and wasteful steps within a process and producing at a faster rate (Bhamu and Sangwan, 2014; Cudney and Elrod, 2011).

2.4.1 Lean Manufacturing and its techniques

Lean manufacturing techniques were the primary methods for improvement in both 2005 and 2006, explains Blanchard (2006). Abernathy et al. (2000) found that many retailers have incorporated lean principles into their inventory decision analysis by using SKU-level analysis (SKU, stock keeping unit), which has put increased pressure on suppliers to deliver goods quickly to the marketplace. The objective of lean is to create the most value for the customer while consuming the least amount of Resources to design build and sustain the product. Improvements can be made by implementing lean tools and techniques appropriate to the particular situation (Sharon A. Schweikhart, 2016).

Is a comprehensive set of techniques which when combined allows you to reduce and eliminate the wastes. This will make the company leaner, more flexible and more responsive by reducing waste through continuous improvement by flowing the product or service at the pull of your customer in pursuit of perfection (Mezgebe, August 2013). Thus the organization who wants to implement lean should have strong customer focus, should be willing to remove wastes from the processes they operate on daily basis should have the

motivation of growth survival. There are numbers of Lean Manufacturing tools when used in proper ways will give the best results. Once the source of the waste is identified it is easier to use the suitable lean tool to reduce or eliminate them and try to make waste free systems. Top 25 lean tools has been found (Sharon A. Schweikhart, 2016), out of which more relevant tools related to garment companies are Kaizen, Kanban, Poke Yoka (Mistake proofing devices), Takt time (line balancing) cycle time, Cell layout (Group technology), 5S (Work place organizations), Visual stream mapping (VSM), Ergonomics work (Safety health and environment), Reduce set up time or Single minute die exchange (SMDE), Point of use system, Small lot size, Supplier management, Total productive maintenance (TPM), Multifunction employees, Uniform workload, Employee involvement (Quality circles), Total quality management (TQM), Training, Teamwork, Production smoothing, Work standardization, Visual management, Fishbone diagram (Ishikawa diagram), JIT (pull demand model), Visual displays and control, Operational planning (Jeyaraman, 2015).. An initial conceptual model of lean tools and principles was developed as shown in Figure 1. A total of 20 tools were identified and these were grouped into six categories: Visual Management, Policy Deployment, Quality Methods, Standardized Work, Just-In-Time and Improvement Methods. The focus of all these tools is meeting customer requirements which are the centre of the model.

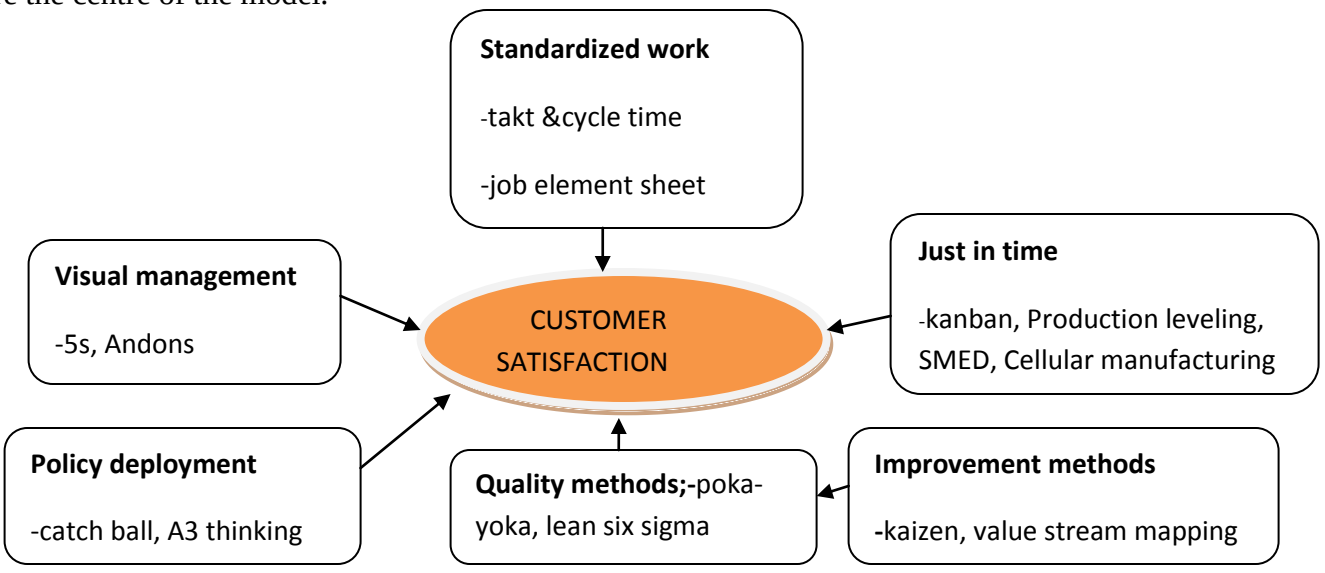


Figure 2.1. Conceptual model of lean tools and principles (Jeyaraman, 2015)**.**

A vital component of **visual management** is the 5s organization system. The 5s tool as Hirano (1996) teaches a structural system to organize any type of business or operation, and 5s represents five steps including sort, set in order or place, shine or scrub, standardize and sustain. Total productive maintenance (TPM), as introduced by Nakajimi (1988), assigns basic maintenance work such as inspection, cleaning, lubricating, tightening, etc., to the operator. This frees up the technicians or maintenance team for productive maintenance, which includes higher value-added activities such as equipment improvement and overhauls, training, etc. Just as in safety the target is zero incidences, in Total Productive Maintenance the target is zero breakdowns (Mahmood, 2015).

Quality methods include Jidoka, Poka-Yoke and Lean Six Sigma. Poka-yoke, as introduced by Shingo (1985a), is implementing simple low cost mistake proofing devices that detect abnormal situations before they occur or once they occur stop production to prevent defects (Prajapati Brijeshkumar, 2016).

Standardized work is the safest, easiest and the most effective way of doing the job that we currently know, but the purpose of standardized work is to provide a basis for improvement on that job. Dennis (2002) found that the goal should be to optimize the utilization of people instead of machines, because the flexibility of people provides more benefits than machine utilization (G. Vijayakumar, 2016). **Just in time** includes Kanbans, production leveling, single minute exchange of dies (SMED) and cellular manufacturing. SMED is a series of techniques developed by Shingo for reduction in production changeover time to less than 10 min. Shingo (1985) has compiled this methodology into his book entitled A Revolution in Manufacturing: the SMED System.

Improvement methods include Kaizen, Kaizen Blitz and VSM. Ortiz (2006) identifies Kaizen as a team approach to quickly tear down and rebuild a process layout to function more efficiently. Russell and Taylor (2002) use the term Kaizen Blitz to describe when a process is quickly changed to eliminate activities that have no value. Womack and Jones (1996) found that for almost all companies, value stream redesigns are a critical step to becoming lean; the design of the end-to-end value stream must be considered instead of applying tools randomly, to address an apparent problem. VSM is used extensively\ in Six Sigma Methodology and Henderson and Larco (1999) recently added the procedure to the list

of tools which can be used to apply the principles of lean. Seth and Gupta (2005) present a case study of VSM as applied to an Indian automotive manufacturer showing both current-state and future-state maps (Rothenberg, 2016).

However, the concept of Lean Manufacturing is still relatively new for these industries except some garment industries like (Almeda Textile plc, Adwa), (MAA garment and industry plc Mekelle) which is introducing kaizen system. Still any studies or implementation related to the production system or lean Manufacturing systems for Ethiopian garment industries are very little. Similarly, the case company follows the traditional production system (Matebu, 2002) (Mezgebe, August 2013).

2.4.2 Lean tools

According to Prathamesh P. et.al (2012) Lean tools have not been derived or proposed in one single day. They have been derived from there people throughout the history. As they are why very complex & interdependent on each other and one can find similarities in one another.

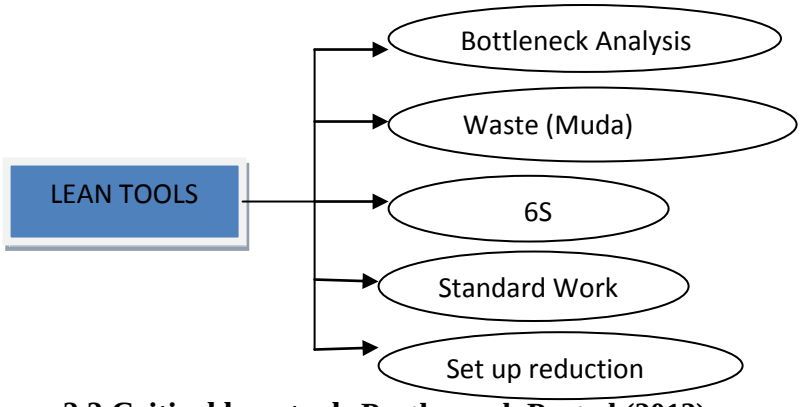


Figure 2.2 Critical lean tools Prathamesh P. et.al (2012)

Currently in practice, there are approximately 25 Lean Tools, out of which, these five tools are considered to be the most critical Lean Tools of all, as shown in the above figure

Bottleneck Analysis A point of concourse in a machine or system that work load gathers at a point in the system that specific point can hope to maintain them. The fetched about by the bottleneck often make longer overall cycle time (Králová, 2010). According to kralova, (2010) a bottleneck is a phenomenon where the competency of a complete system or line is restricted or limited by a single or limited number of components or resources & analysis of

such event is called as Bottleneck Analysis. Hence, Bottleneck Analysis is nothing but the identification which part/machine of the manufacturing process/line limits the overall output and focuses on improvement the performance of that part/machine of the process/line (Derya Sevim Korkut, 2009). Bottleneck Analysis is usually done along with the Time Study Method in the form of 'Daily Analysis', 'Minute to Minute Analysis; or 'Macro Second Study Analysis' the entire process is carried out along with the guidance of Time Study Methods (Derya Sevim Korkut, 2009).

Wastes (MUDA)

Anything in the manufacturing process that to the product from the customer Waste. In simple Language, It is nothing but any process for which the customer does not pay the company. There are 7 types of wastes transportation, inventory, motion, waiting, over processing, over production and defects (rework, scrap) (Khalil A. El-Namrouty, 2013).

6S; - An established methodology procreating in Japan that, when implemented, mitigates the waste of resources and work area in spite of increment in manufacturing & operational proficiency (Derya Sevim Korkut, 2009).

According to Derya Sevim Korkut (2009) the 5S elements are translated in English are Sort, Set-in-Order, Shine, Standardize and Sustain and are applied in various industries to achieve lean manufacturing & to ultimately improve productivity Idea of 5S can be explained by following.

- **Sort:** Completely Sort out & classify that which item is required and/or not required in the work area(eliminate that which is not needed, separate the essential from non essential)
- **Set in Order:** Arrange items in required order that are important so that they are ready to find & easy to use (organize remaining items, a place for everything and everything in its place).
- **Shine:** Clean the work area, tools, machine & equipments on a continuous basis in order to identify defects& maintain standards.
- **Standardize:** Ensure standard & uniform procedures and methods throughout the operation to promote changeover(write standards for above, ensures we don't do what we always did)

- **Sustain:** Stay to the regulations to maintain the standard & continue to improve every day (regularly apply the standards, make the other part of everything life to maintain improvement).
- **Safety:** the condition of being protected from or unlikely to cause danger, risk, or injury.

It helps by Eliminates waste those results from a poorly organized work area (e.g. wasting time looking for a tool).

Standardized Work (SDW) Standardized work is a collection and implementation of the best practices known to that point. It includes what is mandatory to begin the procedure and the completed state of the same. Standard Work is the sequential method for defining the best practices and ensuring that every operator is strictly following them to endow the value to the customers (Patel Chintan Kumar, 2013). Because improvements in safety, quality, productivity & profitability will arise from time to time & the standardized work is to be updated via work instructions document, training, and practice. These are the methodologies that improve quality, safety, productivity & profitability. Basically, standardized work consists of four elements (Patel Chintan Kumar, 2013) (Khalil A. El-Namrouty, 2013):

- Takt time;-which is the rate at which the products must be manufactured in order to meet customer demand on time.
- The accurate work sequence in which the operator performs tasks within takt time.
- The corresponding inventory, including jobs in required maintaining the process operation smoothly.
- The dexterity of the operator & the maneuverability of the machine or system.

✓ **Steps Involved in Standardized Work**

1. Identify and define the best system that bestows a quality result, consistently.
2. Document the steps for performing the best practice, and make it visual using combination of pictures and text.
3. Place it at each work station where this process is being performed by the operator.

4. Train the operators to do the tasks as defined in the Standard Operating Procedure. Standardized work adds regimentation to the abidance, an element that is frequently neglected but essential for lean to foundation.

- ✓ **Setup Time Reduction** or Change-over Time Reduction is defined as the efficient reduction time to change from the last item of the previous order to the first good item of the next order in order to obtain increased productivity (Patel Chintan Kumar, 2013).

2.4.3 Effectiveness of Lean Effort

There is a real connection between lean and the competitiveness of the company's parameters and such parameters that certainly affected by a successful lean effort are: Quality, Cost, Flexibility, Delivery reliability, Delivery time (G. Vijayakumar,2016). Other factors that makes lean more effective and related to strengthening the workforce's welfare, driving force, motivation and influence. Examples of such lean effects are: Reduced stress, increased competence, improved cooperation, Reduced Frustration Improved customer communication, Broader and more developing tasks, improved safety at the workplace, Job Security These positive effects can play a vital role in the long run to accomplish Lean; there is something in it for everyone (Morse, 2014).

2.4.4 Lean Principles

Lean is focus on steady striving to eliminate waste. It is achieved through continuous exercise to visualize and resolve the deviations in an operation. A deviation is something that deviates from what is normal and can be perceived as defined and specific waste. Perhaps every organization agrees that waste should be eliminated, but the question is how. Here Lean principles have an important task in providing guidance. In order to be successful in Lean effort it is necessary for an organization that its values are aligned with the Lean principles (G. Vijayakuma,2016).

Lean methodology has five principles according to "Womack and Jones " and they are defined as: Identify value from customer point of view, Value stream mapping (process map), Create flow – redesigning processes to minimize waste and optimize customer service, Establish Pull – produce when it is needed to fulfill customer demand and Pursue perfection – Zero Defects (Rajenthirakumar, 2015) (Prajapati Brijeshkumar, 2016).

Below are the few steps which are required to implement the Lean manufacturing:

1. Identifying the fact that there are wastes to be removed.
2. Analyzing the wastes and finding the root causes for these wastes.
3. Finding the solution for these root causes.
4. Application of these solutions and achieving the objective.

Apparel Manufacturers are now a day's facing intensive global competition. The key to competing in the international market place is to simultaneously improve both quality and productivity on continual basis. The major purposes of the use of lean production are to increase productivity, improve product quality and eliminate manufacturing waste, reduce inventory and reduce lead time
of the company (Guillory, 2016).
Manufacturing and lean initiatives is criticized that it harbors enormous difficulties (Denton and Hodgson, 1997). Hayes (2000) has stated that successful corporate initiatives like Lean Manufacturing should be properly planned prior to its implementation. Holland and Light (1999) have asserted that in an attempt to implement improvement in organizational productivity, businessmen should have a clear vision and strategy in forecasting project's possible costs incurred and duration of such project.

2.5 Work study

It is a method of measuring work for recording the times of performing a certain specific task or its elements carried out under specified conditions. An operator does same operation (task) throughout the day. Time study help to define how much time is necessary for an operator to carry out the task at a defined rate of performance. This is a technique used to establish a Standard time for a job or for an operation. According to ILO, Work study is used to embrace the technique of method study and work measurements which are employed to ensure the best possible use of human and available resources in carrying out a specified activity (Prajapati Brijeshkumar, 2016). The objective of applying work study is to obtain the optimum use of the human and material resources, which are available to it. The benefit may

stem from improvements in one or more of the following: increased production and productivity, reduced cost-labor, material, overheads, improvement of conditions, which involve an element of excessive fatigue or danger, improved quality and better control of cost (Mezgebe, 2013).

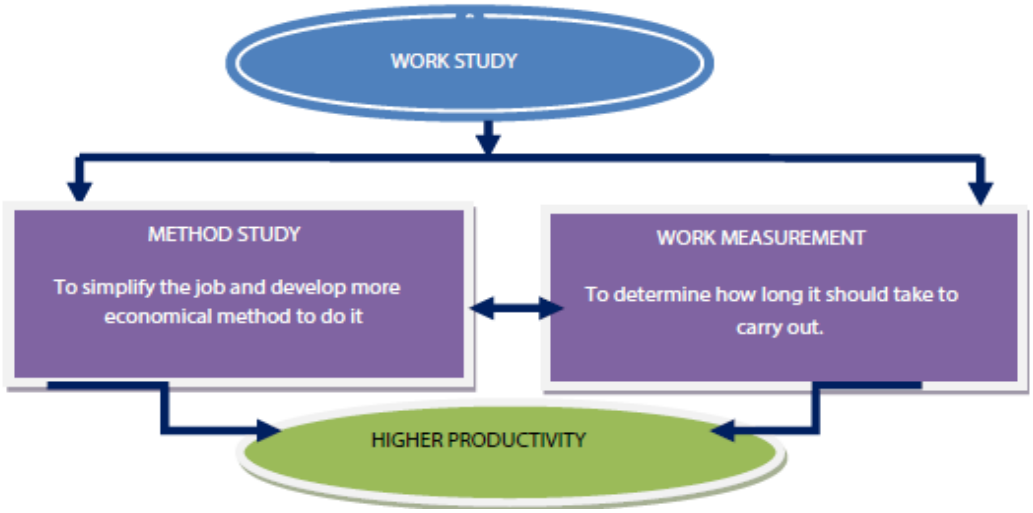


Figure 2. 3 The diagram shows how work study helps in increasing productivity (Jain and Aggarwal, 2013).

According to Jain and Aggarwal method study has been considerable amount of work content is reduced in the new improved method. Then time study has been taken by stopwatch and determined the basic time for all operation sequences and the capacity of each workstation per day has been calculated. By applying method study and work measurement in the industry at production line-Surma for ladies bag, productivity has been improved by 12.71%.

2.5.1 Techniques of Work Study

1. *Method Study:* Method study is the systematic recording and critical examination of existing and proposed ways of doing work. It is concerned with the reduction of work content of a job or operation. Sometimes it is called Work Method Design (Kulkarni, 2014). This method consist tools such as Process flow chart, man machine chart.

The following steps depict the procedure for creating a method study.

1 .Select (the work to be studied), 2. Record (all relevant information about that work), 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)

2. *Work Measurement:* estimation of standard time for an activity that is the time specific for completing one job by using the predicted method. Standard time can be defined as the time utilized by an average experienced skillful operator for the job with provisions for delays beyond the operator's control (Mahmud F. N., 2015).

After the job of interest has been selected, work measurement can be examined 1) Recording all information about the job, 2) Breaking the job down into elements, 3) Examining those elements and determining the sample size, 4) Recording the time to perform each element using a stop-watch,

5) Assessing the speed of working, 6) Converting the observed time to basic time, 7) Determining the allowances, and 8) Determining the standard time (Pisuchpen, 2014).

A work has to be measured to identify and eliminate missing or ineffective time, to install standard times for performance & quality measurement, to measure performance against original expectations and to set manufacturing & operating objectives (Kulkarni, 2014).

2.5.2 Techniques of Work Measurement: The work measurement is carried out by using following principal techniques (ILO, 1986). It is a method of measuring work for recording the times of performing a certain specific task or its elements carried out under specified conditions. An operator does same operation (task) throughout the day. Time study help to define how much time is necessary for an operator to carry out the task at a defined rate of performance. This is a technique used to establish a standard time for a job or for an operation.

2.5.2.1 How work measurement (Time Study) is conducted

An operation cycle consists of material handling, positioning and aligning parts, sewing, trimming threads and tying and untying a bundle. So in the time study format, divide whole task into various elements according to the motion sequences of the operation (Abruzzi, 1952). Hence the operator will be ready to pick other parts so that from the picking up to disposing of the specific operation is considered about a cycle for one operation elements of the shirt.

A) Calculation of SAM or SMV of a Garment

SAM or (Standard Allowed Minute) is used to measure task or work content of a garment. This term is widely used by industrial engineers and production people in the garment manufacturing industry. For the estimation of cost of making a garment SAM value plays a very important role (Derya Sevim Korkut, 2009). According to Abruzzi (1952) Standard allowed minute (SAM) has been defined for each movement needed to accomplish a job. General Sewing Data (GSD) has defined set of codes for motion data for SAM calculation. There are also other methods through which one can calculate SAM of a garment without using synthetic data or GSD. Two methods have been explained in the following (Md. Abdul Moktadir1*, 2017).

A 1) Using synthetic Data

In this method 'predetermined time standard' (PTS) code are used to establish 'Standard Time' of a garment or other sewing products.

Step 1: Select one operation for which want to calculate SAM.

Step 2: Study the motions of that operation. Stand by side of an operator (experienced one) and See the operator how he/she is doing it. Note all movement used by the operator in doing one Complete cycle of work. See carefully again and recheck the note if all movement/motion are Captured and correct. (For example motions are like -pick up parts one hand or two hands, align Part on table or machine foot, realign plies, etc.)

Step 3: List down all motion sequentially. Refer the synthetic data for TMU (Time measuring Unit) values. For synthetic data can refer GSD or Sewing Performance Data table (SPD). Then get TMU value for one operation (for example say it is 400 TMU). Convert total TMU into minutes (1 TMU=0.0006 minute). This is called as Basic Time in minutes. In this example it is 0.24 minutes.

Step 4: Standard allowed minutes (SAM) = (Basic minute + Bundle allowances + machine and personal allowances). Add bundle allowances (10%) and machine and personal allowances (20%) to basic time. Now got Standard Minute value (SMV) or SAM. SAM= (0.24+0.024+0.048) = 0.31 minutes.

A 2) Using Direct Time Study:

Step 1: Select one operation for which want to calculate SAM.

Step 2: Take one stop watch. Stand by side of the operator. Capture cycle time for that operation.

(Cycle time –total time taken to do all works needed to complete one operation, i.e. time from Pick up part of first piece to next pick up of the next piece). Do time study for consecutive cycles. Discard if found abnormal time in any cycle. Calculate average of the 8 cycles. Time you got from time study is called cycle time. To convert this cycle time into basic time you have to multiply cycle time with operator performance rating. [Basic Time = Cycle Time X performance Rating].

Step 3: Performance rating. Now have to rate the operator at what performance level he was doing the job seeing his movement and work speed. Suppose that operator performance rating is 80%. Suppose cycle time is 0.60 minutes. Basic time = (0.60 X 80%) = 0.48 minutes.

Step 4: Standard allowed minutes (SAM) = (Basic minute + Bundle allowances + machine and Personal allowances). Add bundle allowances (10%) and machine and personal allowances (20%) to basic time. Now got Standard Minute value (SMV) or SAM. SAM= (0.48+0.048+0.096) = 0.624 minutes.

 Time study*:* technique of work measurement to establish time for a qualified worker to carry out specified task under specified conditions and at defined level of performance. Basic time study equipment consists of – a stop-watch, a study- board and time study forms (Chandra, 2013).

 Work Sampling*:* technique in which a statistically competent number of instantaneous observations are taken, over a period of time, of a group of machines, process or workers. Each observation records what is seen to happen and the percentage of observations recorded for a particular activity or delay is a measure of percentage of time observed by the occurrence (Ephrem, 2015).

 Predetermined Motion Time Study (PMTS)*:* is a technique whereby time established for basic human motions are used to build up time for job at a defined level of performance. It utilized the time study and micro motion techniques (Chandra, 2013).

 Standard Data*:* When similar elements and jobs are present throughout a plant, the standard data system of work measurement can be used. It consists of tables, curves and charts built up from various basic job constituents. Standard data elements must first be measured by any of the three work measurement techniques (G. Vijayakumar,2016).

2.6 Purpose of work study:

In general objectives of work study are to Establish the most economical way of doing the work, Establish the time required for a job at a defined level of performance Increase productivity and profitability, Increase job security, Make work easier, Establish fair tasks for everyone, Check achievements against standards and to Install the work method as standard practice (Olena Grinenko, 2017).

2.7 Importance of work study;-

Better employment prospect, little or no capital expenditure, procedures doesn't overlooked factors affecting situation, set standards of performance and the base for incentive, it take every fact in to account and reveal weaknesses overlooked day to day, Standardize method, materials and equipment used in the production process (Chandra, 2013). Work study is a means of enhancing the production efficiency of the firm by elimination of waste and unnecessary operations, it is the technique to identify non-value adding operations by investigation of all the factors affecting the jobs and it's the only accurate and systematic procedure oriented technique to establish time standards going to contribute to the profit as the saving will start immediately throughout the life of the product (G. Vijayakumar,2016) (Jeyaraman, 2015).

2.8 Role work study to increase productivity;-

There are six possible lines of attack on productivity problems, which can be classified as follows: Improve basic processes by research and development, Improving existing process and provide better plant and equipment, Simplify the product, reduce and standardize the range, Improve the planning of work and the use of manpower, Improve existing methods of plant operation and to Increase the effectiveness of all employees. In production planning and control (PPC), concept of work study plays an important role to increase productivity as it

identifies the problems and provide direction to overcome those (Prajapati Brijeshkumar, 2016). Time study procedure (Prathamesh P. Kulkarni1, 2013)

Step 1. Define objective of the study.

Step 2. Verify that standard method and conditions exist for the operation and the operator is properly trained.

Step 3. Select operator to be studied if there are more than one operator doing the same task.

Step 4. Record information about the standard method, operation, operator, product, equipment and conditions o the time study observation sheet.

Step 5. Divide the operation into reasonably small elements and record them on the time study observation sheet.

Step 6. Time the operator for each of the elements record the data for a few numbers of cycles on the time study observation sheet.

Step7. Collect and record the data of required number of cycles by timing and rating the operator.

Step8. Calculate the representative watch time for each element of operation multiplies it by the rating factor to get normal time.

Step 9.determine allowances for fatigue and various delays.

Step 10. Determine standard times of operation

- Standard time = normal time + allowances.

2.9 Type of waste and its description ;- Ohno (1988) identified seven types of waste in his book Toyota Production System and explained that waste is sometimes hard to see, but can be classified by: overproduction, time on hand, transportation, over processing, inventory, movement and defective products (Mezgebe, August 2013).

1. **Overproduction**;-Producing too much or too soon, resulting from poor flow of information

2. **Defects Frequent errors**; - product quality problems, or poor delivery performance

3. **Unnecessary inventory**; - Excessive storage and delay of information or products, resulting in excess inventory.

4. **Inappropriate processing**; - Going about the work process using the wrong set of tools, Procedures or systems, often when a simpler approach may be more effective

5. **Transportation**; - Excessive movements of people, information or goods, resulting in wasted time, effort and cost

6. **Waiting**; - Long periods of inactivity for people, information or goods

7. **Unnecessary motion;** - Poor workplace organization, resulting in poor ergonomics, for Example excessive bending or stretching and frequently lost items

All the lean tools work towards common goals of eliminating this waste in order to bring the most value to the customer (Bartholomew, 2015). (Habte, 2013).

2.10 Method study and its procedures

Method study is the process of subjecting work to systematic, critical study to make it more effective and/or more efficient. It is one of the keys to achieving productivity improvement. It was originally designed for the analysis and improvement of repetitive manual work but it can be used for all types of activity at all levels of an organization. The process is often seen as a linear, described by its main steps of:

Select (the work to be studied); Work selected for method study may be an identified problem area or an identified opportunity

Record (all relevant information about that work);

Examine (The recorded data are subjected to examination and analysis; formalized versions of this process are critical examination and systems analysis. The aim is to identify, often through a structured, questioning process, those points of the overall system of work that require improvements or offer opportunity for beneficial change).

Develop;- (to do something for improvement); The Examine stage merges into the Develop stage of the investigation as more thorough analysis leads automatically to identify areas of change. The plan here is to recognize possible actions for development and to subject these to evaluation in order to develop a preferred solution.

Install; - change that meets the originally specified terms of reference for the project. Thus, the Install phase is very important. They may need comforting, retraining and sustaining through the acquisition of new skills. Install, in some cases, will require a parallel running of

old and new systems, in others; it may need the build-up of buffer stocks, and other planning to manage the change. What matters is that the introduction of new working methods is successful. There is often only one chance to make the change! Earlier to install the new method, the decision must be taken on:

Ordering of new plants or materials (if any), Phasing in changes in the production process, Deciding the extent of redeployment, Introducing new documentation procedures, Setting new quality standards and test procedures and A detailed timetable for effecting these changes.The end product of the installation stage is that the new method is in operation at the work site; there is a complete control of line management; and finally, all members of the department are fully conversant with the method.

Maintain (the new standard proactive). Sometime after the introduction of new working methods, it is necessary to check that the new method is working that it is being properly followed, and that it has brought about the desired results. This is the Maintain phase. Method drift is common - when people either revert to old ways of working, or introduce new changes. Some of these may be helpful and should formally be incorporated; others may be inefficient or unsafe.

2.11 Relation between Lean and Work study

2.11.1 Why lean and work study?

The current research seeks to better understand the impact on productivity from lean improvements implemented with and work study for a single process improvement framework. A single process improvement framework would allow companies to see benefits in multiple areas and aid the company culture for continuous improvement (Morse, 2014).
Lean emphasizes worker contribution, but too often the job of the human resources organization is overlooked (Bartholomew, 2015). Having good working conditions presents one strategy for attracting and retaining high-quality employees (Dul, 2009). The implementation of the new production system that work study focus on reducing the work

cycle times and task variety, Lean manufacturing for remove waste and increase customer value (Nunes, 2007) (Dul, 2009).

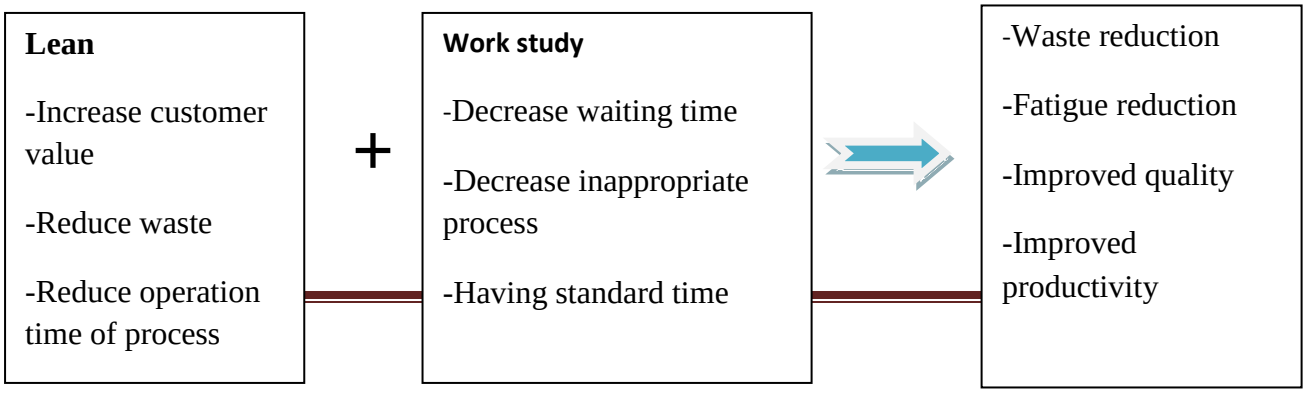
From the seven wastes (Muda) production waiting Time and inappropriate processing are one of the basic wastes that can be significantly reduced with the implementation of work study assist systems. With the correct time and by removing wastes of the product in place, creating an increase in production decreased costs, and increase quality (Walder, 2007).

2.11.2 How lean and work study integrate?

Lean and work study be complementary approaches (Pacheco *et al.*, 2015) and provides a powerful methodology when combined. Lean aim at reducing waste within a process leading to bottom-line improvement by using lean tools. This provides an economic impact to the company along with meeting customer expectations (Rothenberg, 2016).

Table 2.1 The Relationship between lean and work study (Chandra, 2013)**.**

Program	Lean thinking	work study
View of waste	Non value added is waste	waiting time
Applying	-identify value -define value stream -determine flow -define pull -improve process	-select -record -examine -develop -install -maintain
Tools	Visualization	stop watch
Focus	Process flow focused	focus on process



2.12 SPSS the software name originally stood for statistical package for social science. it is the acronym of statistical package for the social science and one of the most package popular statistical package which can perform highly complex instruction. It used by researchers to perform statistical analysis (Mezgebe, August 2013).

2. 13 performance Indicators

The definition of indicators entails some basic requirements:

• Representativeness;

• Simple and easy to interpret;

• Capable to indicate time-trends;

• Sensitive to changes within or outside the organization;

• Easy data collecting and processing;

• Easy and quick to update.

Coordination recognizes the presence of interdependency between processes, activities or functions. Coordination deals with the degree to which the indicators in various related areas.

2.13.1 Performance Indicators functions

A good indicator set directs and regulates the activities in support of strategic objectives and provides real-time feedback, predictive data, and insights into opportunities for improvement Indicators provide a means of "distilling" the larger volume of data collected by organizations. As the volume of inputs increases, through greater span of control or growing complexity of an operation, data management becomes increasingly difficult. Actions and decisions are greatly influenced by indicators nature, use, and time horizon (short or long-term). Indicators provide the following three basic functions:

Each system of indicators is subject to a dynamic tension. This stems from the desire to change indicators in response to new strategic priorities, and the desire to maintain indicators to allow comparison of performance over time. This tension will dictate the indicators life cycle (Fiorenzo, et al., 2007).

There are three types of indicators, which are individually discussed in the three following sections:

1) **Initial indicators**. Indicators of the quality of materials or the quality of services provided by suppliers.

2) **Intermediate indicators**. For example, indicators of a manufacturing process compliance.

3) **Final (result) indicators**. For example, indicators of customer satisfaction or production cost.

2.14 Summary of the Literature

Definitions of work study, the importance of work study the work study problems, time study, waste, and productivity. The usefulness of the work study and lean for the continuous improvement. Also seen the detailed procedures of the main parts. To get enough information about the topic raised so many kinds of literatures are reviewed from different sources, among these journal and articles. During literature survey recent documents concerning lean and work study are collected from different sources then try to see the gaps. The next Table summarizes main articles with regard to lean and work study. The difference between this thesis and the previous thesis done discussed by taking main points that make difference in the preceding chapter.

Table2.2. Summary of main articles

Author	**Title**	**Product analyzed**	**Technique used**	**Benefits derived**	**Limitations**
C. U. Mucella G.Guner, (1973)	"line balancing in the apparel industry,"	T shirt	Work study	Improve the time wastes	Only focus on time wastes
T.Mezgebe (2013)	"Economic Analysis of Lean Wastes:	Shoe	Lean	Reduce rework, waste, flexibility style	Problems not clearly stated

D. D. Prajapati Brijeshkumar, (2016)	Work study,lean manufacturing and six sigma,	Jacket	Lean,six sigma	Improve productivity	Mainly focus on lean and six sigma approaches
R. D. A. a. L. Rothenberg (2016)	, "Lean Six Sigma applications in the textile industry,"	trousers	Lean	Reduce rework, compliance, risk	The findings from this case study cannot be generalized.

Rohana Abdullah1 , Md Nizam Abd Rahman, (2012)	Work Study Architecture for Lean Waste Analysis to Achieve Optimum Man-Machine Configuration	electronics	Lean system	Development and implementation of work study	Show the general architectural view
Syed Asad Ali Naqvi, Muhammad Fahad, (2014)	Productivity improvement of a manufacturing facility using systematic layout planning	Switch gear	Work and method study tools.	This paper illustrates the use of SLP as a simplified approach for layout design.	number of subjective decisions
Mahmood,(2015)	Factors affecting productivity	electronics	Compariso n	Try to show the factors affect production	Show general factors it's not clear
K.eyaraman, (2015)	lean Six Sigma	Garment Product	Lean	Remove time wastes	The sample size is not very large, the results need to be Considered with caution.

Gap of the Literature

The reviewed literatures gap discussed on the above table and most of them are focused on the deployment to solve the problems. Integrated Lean and Work study approach in Industries is not explored and not much has been found in Ethiopian context and Very little literature is available on integration of Lean Manufacturing and work study focusing on garment industry.

CHAPTER THREE

RESEARCH METHODOLOGY AND MATERIALS

This chapter discusses the methods that were used in the collection and analysis of data to answer the research questions. Both qualitative and quantitative research methods were used in carrying out this research.

3.1 Data Source and Research Methodology

Different sources are identified and used during the research period for the purpose of getting an input for the methodologies of the research. The methodology applied in the research includes Literature review, primary and secondary data collection methods.

1. Literature Review: different recently published journal articles, proceedings and books were surveyed in order to understand the concept, principle and benefit gained by implementing lean, and work study together. Also the review process helps to identify improvement tools, different wastes, physical and working environment factors, equipment, work procedure that affect production process and the performance of operator.

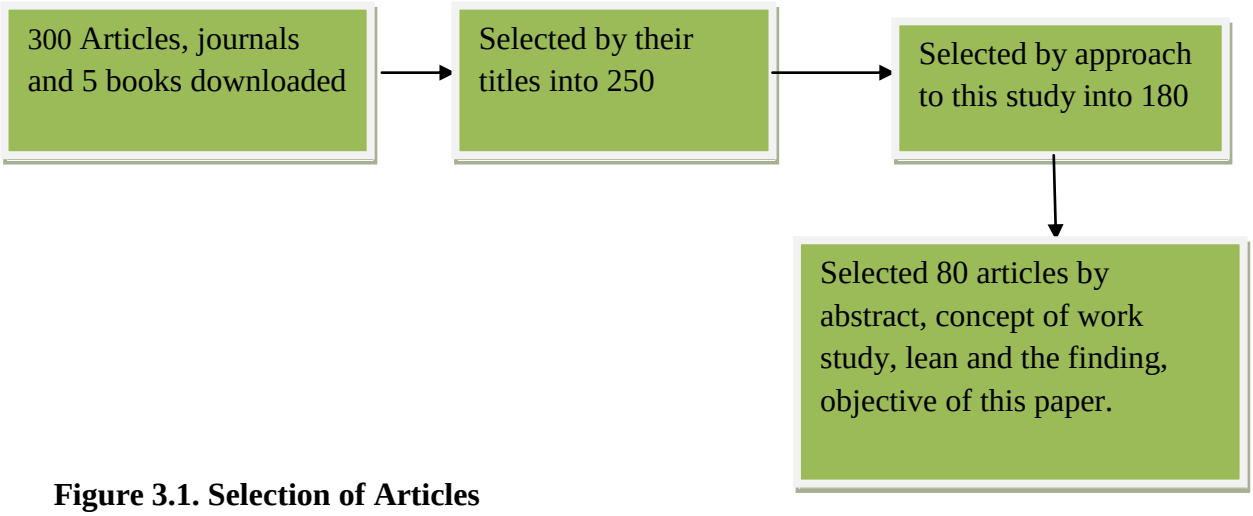


Figure 3.1. Selection of Articles

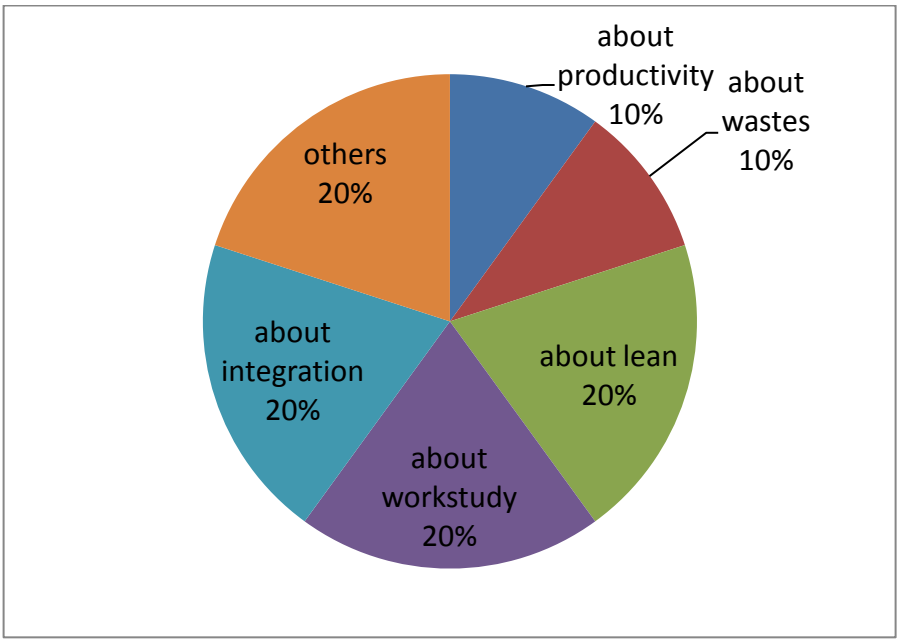


Figure 3.2. From over all the literatures main points focused in percent

2. *Primary Data:* The data primarily obtained was through continues assessment of the field study,

Questionnaire, informal communication with manager and shop floor workers to get better understanding of the problem area.

I. Direct Observation (Descriptive observation) - during visiting of the case company necessary data gathered through careful observation of operator movement, material handling, work station design, working environment, process flow and time study of production department.

II. Questionnaire- prepared based on different literatures in the field of productivity, lean, waste and work study and different areas used for manufacturing industries. Structured questionnaires are used to get complete information about the company. The questionnaire is translated from English to Amharic to make suitable for the respondent. The questionnaire is directed to Production department and production area (operators) of the company. Most questioners are close- ended. They give rank

- Rank 5=excellent
- Rank 4=very good

- Rank 3=good
- Rank 2=fair
- Rank 1=poor

The questioner designed and distributed for 100 workers of the company from those 80 give response which is 74% of the population size.

III. **Interviews** -In-Depth Interviews to get the exact information, include individual interviews as well as "group" interviews production managers, operators. The data can be recorded in written notes.

IV.**Using stop watch-** Time study has been taken by stopwatch and using time sheet to determine the basic time for all operation sequences and the capacity of each workstation per day.

3. Secondary Data: secondary data used in this research includes different documents regarding from previous documents, government and non-government institutions.

Document review- to show the existing problems of productivity in the case company different company documents are reviewed such as production and quality records, attendance sheet and other related report on the company from external sources.

Statistical data- conducted using data from textile and garment industry development institute, from Addis garment (Augusta) sc.co and previous thesis focus on export performance of the sub sector.

3.2 Sampling Strategy

This section consist description about the target population, sample size and the sampling procedure used to evaluate the current observed time of each element.

3.2.1 Target Population

According to Fraenkel et.al (2002), population refers to the complete set of individuals (subjects or events) having common characteristics in which the researcher is interested (Legesse, 2016). The target population of this study includes operators, maintenance, quality controls and supervisors working on the shop floor. As of April 2017 report there are a total of 320 man power. From this 276 are female and 26 are male. From this 302 employees are direct labors engaged in production; the remaining staffs are working in administrative area.

3.2.2 Sample Size

The sampling method which applied in this study is the simple random sampling method. A simple random sample is a sampling method in which every member of the population has an equal and independent chance of being chosen. To get a representative and reasonable sample size that supports the research findings, the following equations were used. Equation (1) is applied to compute the initial sample size. Since the population is finite (less than 50,000), Equation (2) is used to compute the new sample size. These equations developed by Johnson et.al, (2009) and Freedman et al., (2007) according to (Othman, 2014).

$$n_0 = \frac{Z^2 * p(1-p)}{c^2} \quad \ldots\ldots (1) \qquad\qquad n_f = \frac{n_0}{1+\frac{n_0-1}{N}} \quad \ldots\ldots\ldots (2)$$

Where:

no = initial Sample Size

nf= target sample size

Z = Z-values for confidence levels are (1.645 for 90% confidence level, 1.96 for 95% confidence level and 2.576 for 99% confidence level)

p = percentage picking a choice, expressed as decimal 0.5 used for sample size needed

c = confidence interval, expressed as decimal; 0.08 = ±8

N = Population = 302 workers

$no = \frac{1.645^2 * 0.5\ (1-0.5)}{0.08^2} = 211.40$

$nf = \frac{211.40}{1+\frac{211.40-1}{302}} = 124.6 = 125$

3.2.3 Sampling Procedure

Stratified random sampling is used to get the desired representation from the various employees' subgroups in the population. The subject was selected in such a way that the existing subgroups in the population are more or less reproduced in the sample. After sampling at each subgroup, simple random sampling proportional to size based on the

relative number of employees in each section was used. A sample should be optimum; fulfills the requirements of efficiency, representativeness, reliability and flexibility (Kothari, 2004).Proportionate allocation was used by sampling fraction in each of the strata that is proportionate to that of the total population.

Table3.1. Target respondents

Section	Responsibility	Total staff	Sample size
Cutting	Quality control	2	2*(125/302) = 1
	Operator and helper	15	15*(125/302) = 6
Stitching	Quality control	3	3*(125/302) = 1
	Operator and helper	187	187*(125/302) = 77
	Supervisor	5	5*(125/302) = 2
Finishing	Quality control	5	5*(125/302) = 2
	Operator and helper	80	80*(125/302) = 33
	Supervisor	5	5*(125/302) = 2

3.3 Tool and Method of Data Analysis

Tool selection;-is the task of selecting tools or methods from a set of candidate tools, given data in the simplest cases, a pre-existing set of data is considered From referred articles try to separate the tools majority of them used.

The data will analyzed by taking the information from primary and secondary sources. During analysis of the data Microsoft Office 2010 Excel used to manipulate the raw data collected from the sources and the response rate of questionnaire, interview and statistical data.Also it is used to present the result of the data through different charts; **cause and effect diagram** to show the factors of low production (wastes), **pie chart** to illustrate percentage share of sections, **bar graph** to show the status of each parameter and **SWOT analysis** to know the strengths, weaknesses, opportunities and treats. The strength and weakness are internal and the opportunities & treats are external aspects or factors of (Ethiopian textile and garment). “Lean” tools such as 6S. Using **stop watch** to measure (observe) the production time per minutes that each elements take (evaluate the working time).mathematical analysis for check the validation of the model.

And different calculations Johnson et.al (2009) (Adam, 1952)

- ✓ Required sample size = n = $(\frac{zs}{hx})^2$
- ✓ Average observed time = $\frac{\text{Sum of the times recorded to perform each element}}{\text{Number of observations}}$
- ✓ Normal time= observed time * Rating
- ✓ Standard time = $\frac{\text{total normal time}}{1- \text{ Allowance factor}}$
- ✓ SMV= basic time + allowance
- ✓ Down time = $\frac{\text{total down time}}{\text{Total working time}} * 100$
- ✓ Productivity = $\frac{\text{output}}{\text{Input}}$

3.4 Validation of data/ reliability testing;- Cronbach's alpha is a coefficient of reliability. Is a measure of internal consistency, how closely related a set of items are as a group. It is considered to be a measure of scale reliability, a high value for alpha does not imply that the measure is one-dimensional. (Reliability coefficient of 0.70 or higher is considered acceptable) (Changiz, 2011).

Table 3.2 Cronbach's alpha result for each productivity measurements

Productivity improvement measures	Reliability statistics	
	Cronbach's alpha	**No of items**
Customer requirement	**.749**	**7**
Internal process (Idle time)	**.927**	**6**
Waste minimization	**.943**	**7**
Continuous improvement	**.701**	**5**

As the studies of (Syum, 2010), (Changiz & Azadeh, 2011) states the 0.70 Cronbach's Alpha value is a "commonly used threshold for acceptable reliability", and thus, is considered acceptable as table 5.1 shows, all alpha scores for each business measures were in the acceptable range from 0.701 to 0.943.

3.5 Dissemination of the study; - this study consider the textile production sector of target audiences and the setting in which research findings are to be received where appropriate communicating and interesting with wider policy.

3.6 Ethical consideration

Respect for the dignity of research participants should prioritize, Protect of the privacy of research participants has to be ensured and adequate level of confidentiality of the research data should be ensured.

3.7. Research Design

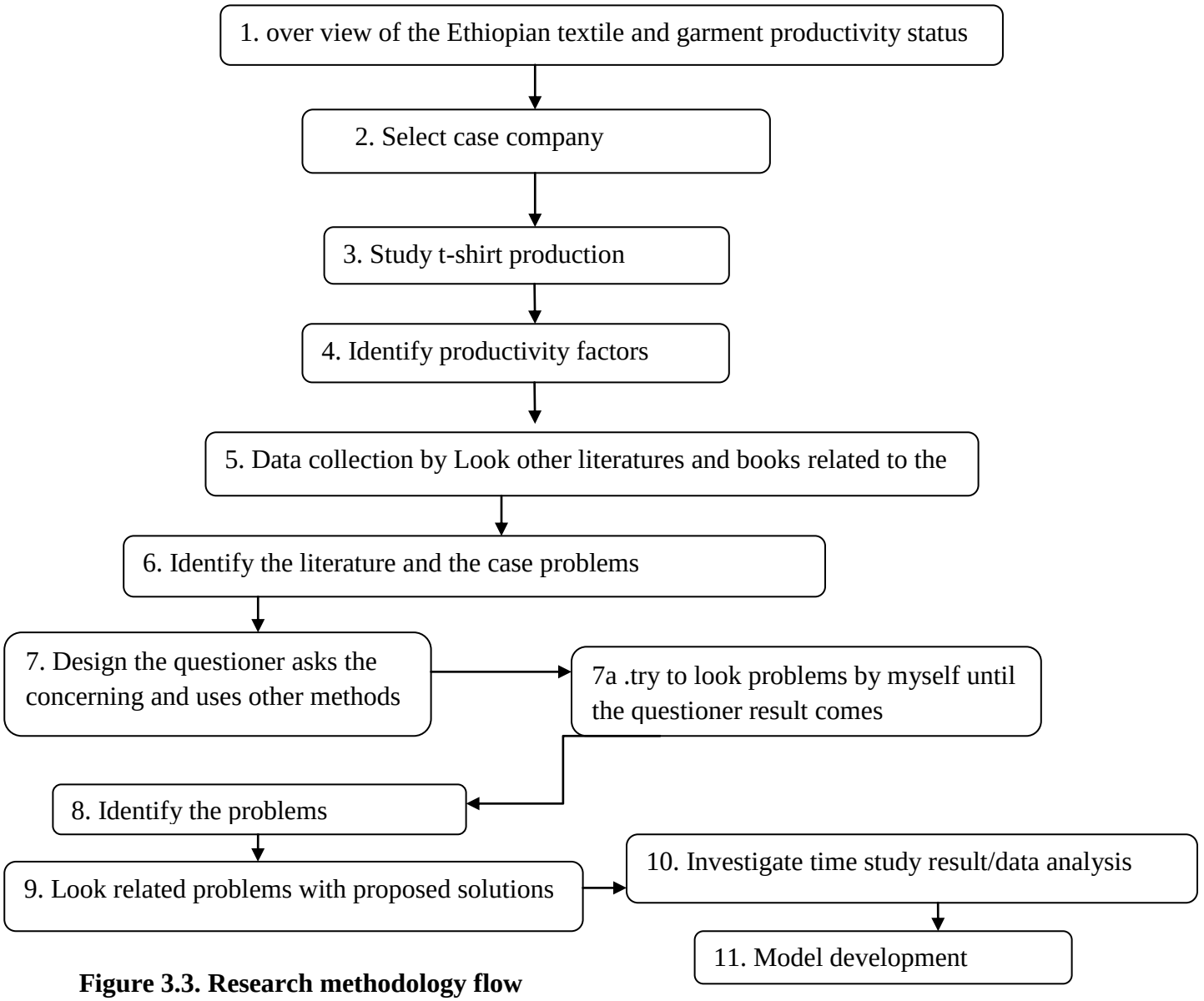


Figure 3.3. Research methodology flow

CHAPTER FOUR
Overview of the Ethiopian Textile and Garment sub-sector

4.1 Historical Background of Textile and Garment Industry

Textile and garment is one of the world's biggest consumer goods categories with a global market estimated to be worth well over one million Euros. Nowadays global competitions in textile and garment products become very intensive. In general it is possible to observe the situations of textile and garment competitions in three categories .Textile and garment manufacturing in developed, developing and under developing countries (Mahmud F. , 2015).

Throughout the 20th century Europe was the sectors number one producer and trader at each of the many stages of fabric production as well as in garment making and in the fashion industry. Over the past two decades since 1986 however, this industrial fortress has been subject to constant wear and tear. The competitive battle begun primarily in the labor-intensive clothing sector. Whole areas of which have migrated to low wage countries (Matebu, 2002).

Over the last 25 yrs (1979 -2005) the US textile and apparel industries have experienced what has been the best chapter in their collective history. As a result of adverse economic circumstances, structural changes in distribution, developments in new technology and above all a sharp escalation in international competition, the textile and garment industries have been forced to undertake massive strategic changes. In the process, there have been many plants closures (Matebu, 2002). Most of the developed countries using assembly line balancing system that's why they compute the global market easily because of them high productivity.

From all developing countries China could be taken as the best example textiles have always been one of china's most important industries. When the process of economic reform began in china 1979.china textile and garment industries using assembly line balancing system which are highly competitive in international terms became a major source of exports (Bahadir, 2011) (Dr.K.Arulselvan, 1927).

Some of the oldest surviving African textiles were discovered at the archaeological site of Kissi in northern Burkina Faso. They are made of wool or fine animal hair in a weft – faced plain weave pattern. Further cloth fragments date to the ninth century from sites at Igbo Ukwu of the people of Nigeria. The knowledge of weaving and fabric production has existed for centuries throughout the continent during the Trans-Atlantic slavery; many skilled weavers were taken and took their knowledge along with them to North America, South America and the Caribbean (Raffia N. B., 1989).

The under developing countries most of them don't use the assembly line balancing system so, they couldn't compute with the global markets. Ethiopia is located at the center of the world with easy access to international value chains and has access to a state of the art and has potential to develop competitive cotton or textiles industry due to good climatic and soil conditions together with cheap hydro-energy. Duty free access to the Europe union and us markets through the African growth and opportunity acts.

4.1.1 Overview of the Ethiopian Textile and Garment sub-sector

Today's business climate for clothing manufacturers requires low inventory and quick response systems that turn out a wide variety of products to meet customer demand. It is especially in the apparel industry that managers are trying to develop their current systems or looking for new production techniques in order to keep pace with the rapid changes in the Fashion industry (Mucella G.Guner, 1973). Textile and Garment factories become a wide value in Ethiopia. The garment industry produces different kind of garments like (shirts, t-shirts, working cloths and trousers and others) on their manufacturing area (Pianthong1, The Assembly Line Balancing Problem :, 2007). Over 65 textile investment projects from international investors have been licensed in Ethiopia since 1992 with retailers such as H&M and Primark already sourcing clothing from Ethiopia (Matebu, 2002).

4.1.2 Export performance of Ethiopian textile industry in GTP I and GTP II

Ethiopia's Textile Industry Development Institute (TIDI) has forecast $ one billion in annual revenue from textile and garment export during the second phase of the growth and transformationplan(GTPII),.

In a bid to make the nation the major exporter of textile products, the government has

extended attractive incentive packages to boost production of the manufacturing industry subsector. Under the Growth and Transformation Plan (GTP), the Ethiopian Government has targeted to achieve $1 billion in exports of textiles and apparel during 2010-11 to 2014-15 period. However, the performance of the Ethiopian textile and apparel exports during the first three years of GTP period was only $305 million, much below the $637 million envisaged during the period under the GTP.

In 2012-13, Ethiopian textile and clothing exports fetched US$ 99 million, which was much lower than the Government target of US$ 357 million for the financial year. Even if there are over 100 companies operating in the Ethiopian textile and clothing sector, during the nine-month period of 2013-14, only 16 companies together accounted for more than 80 percent share in export of textiles and apparel, according to textile industry development institute (TIDI). In the first quarter of 2014 the figure was earmarked at USD 29 million. The above mentioned figure indicates the presence of variety of problems in the sector contribute for the failure to meet the targeted revenue. . To solve the above problem the factory use disorganized and reactive problem solving approach which is not effective for improving productivity in a continuous manner. The main reasons for not using organized and continuous productivity improvement program are lack of understanding and commitment from top management As (Matebu, 2002) mentioned on the study conducted in Harer Brewery S.C and some other Ethiopian manufacturing firms‟ those implemented Kaizen philosophy; Most organizations start improvement notion to come up with a solution to their problems but, they ignores continuous improvement effort Some of the problems associated with Ethiopian garment industries are lack of knowledge about the marketplace and their competitors, unsuccessful process and product innovation schemes, ineffective production planning and controlling systems, absence of coordination between suppliers, customers and industries, absence of quality concepts and modern management practices, and ineffective financial and human resource management's .International (Mucella G.Guner, 1973).

Table 4.1 Export performance of Textile and Garment in GTP I and GTP II ***Source: (TIDI, 2014)***

Year	2010	2011	2012	2012 -2013	2013 -2014
Plan	1 billion$	1billion$	1billion$	357 million $	350 million $
performance	305 million $	305 million $	305 million $	99 million $	29 million $

From the above table we can understand the export plan and the productivity performance not balance or not fulfill the GTP plans. It means the productivity level is too much low.

Ethiopia textile and garment firms are not in a position to compute in the international markets due to the problem such as low productivity, limited quality awareness, limited capability of own design development, inefficient management structures and other problems (Raffia N. , 2000).

4.1.3 SWOT Analysis of Ethiopian textile subsector

SWOT analysis is a study to show the Ethiopian textile subsector strength, weakness, opportunities and threats.

Table 4.2. SWOT Analysis of Ethiopian textile subsector (Matebu, 2002)

Strengths	**Weakness**
➢ Suitable weather conditions ➢ Abundant fertile land ➢ Advantage of low labor cost ➢ water resources ➢ The sector is in the priority list of the Government program.	➢ Absence of scientific research and development. ➢ Lack of integration ➢ Lack of skilled human resources ➢ Insufficient irrigation works ➢ Poor market information channel ➢ Poor quality and productivity ➢ Poor infrastructure
Opportunities	**Threats**
➢ Vast international and regional market ➢ Potentials for expanding cotton planting area ➢ Potential of high trainable labor force ➢ Potential to increase yield per unit area	➢ Stiff global competition ➢ Limited capacity of capital for infrastructure ➢ Commitment to continuous change

4.2 Company background (Addis Garment (Augusta sc.co))

Addis Garment Sc. selected for the study because of the following main reasons:

1. Long time work experience it's more than 40 years.
2. The largest producer of shirts relative to other factories

Figure 4.1 Logo of the case company

Addis Garment S.C Augusta; - Addis Garment Share Company, previously known as Augusta, was established in 1965 as a private company by three Italian Nationals. The Factory came under public ownership in 1975 along the nationalization drive of the Military Government. Addis Garments Share Company was transformed into a Share Company in accordance with the approved privatization strategy and has been privatized in April 2006 and has been bought by three other Italians.

The main objective during the establishment was to produce different types of shirts and work wear for the export and local market from imported as well as from locally made fabrics. In the past years the factory has been producing shirts, work wear and graduation gowns for the local market and for export .The factory maintains a total land area of 8,621 square meters, which accommodates production halls, stores, offices and including other staff facilities has been completely renovated. Addis Garment is located in the heart of Addis Ababa, Kolfe Keranio sub city, Woreda 9 and House No.918. It is located on the ring road that passes through Bole international airport.

Figure 4.2. Over view of the Company

Addis Garment S.C (Augusta) was established with the aim of producing quality shirts and later on started to produce different types of product items such as over all, under wear and working dresses with different types but currently specialize on men shirts. Quality is a key factor that will help us sell our brand which is why we have but in place competent quality assurance teams that will ensure that all our clothes meet and even surpass our customers' expectations. More than before, we are working hard to ensure that Addis Garment is not just accepted nationally in Ethiopia, but also in other parts of the world.

Figure 4.3 .Workers in Duty

Mission;-Top manufacture world class shirt of outstanding quality that give our customer a competitive advantage through superior quality and value so we can make our customer smile.

- ✓ Attain high level of efficiency, integrity and honesty.

Vision;-To become a globally prominent shirt manufacturer that can comparable with international standards and be ranked amongst the top garment manufacturer in the world items of quality, service standards and ultimately customer satisfaction.

Values;-Our values are:

- ✓ Team work
- ✓ Customer satisfaction and delight
- ✓ Superior quality performance
- ✓ Passion about excellence ,Fair to all

4.2.1 Products and capacity

Company's main products are five types of shirts. Have one big spreading table and five production lines for stitching .which enabled the company to increase its capacity. Monthly

production rate is 30,000-50,000 per pieces. The factory work only one shift 8 hr/day. It produces finished men shirts in different styles for both local and international market.

Here is the product that fits high quality standards both local and international markets:

Figure 4.4. Main products of the company

Process Flow (production realization in the company)

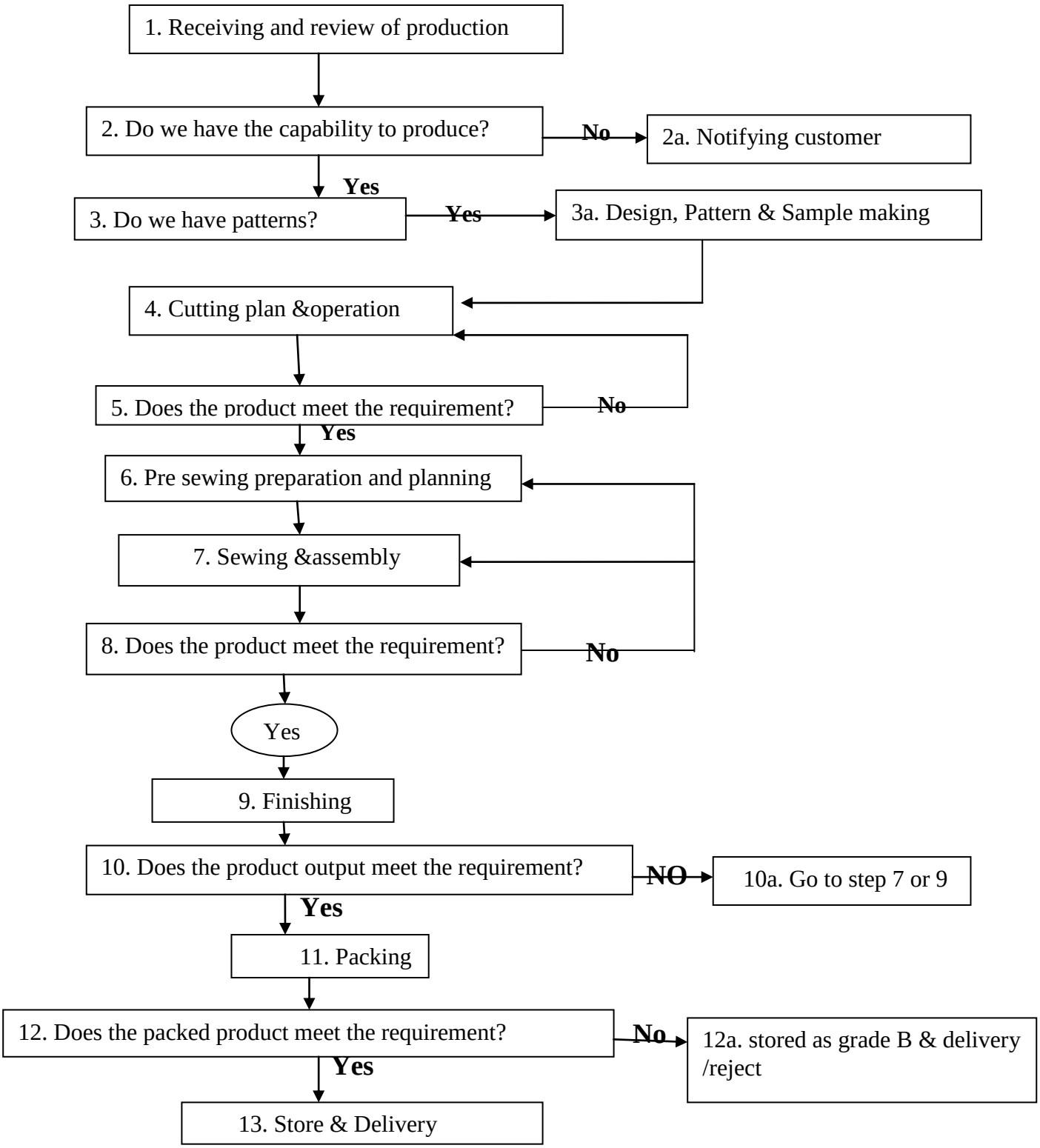


Figure 4.5 process flow of the shirt production

CHAPTER FIVE

Method of Data Collection, Analysis and Interpretations

5.1 Introduction

On this chapter will discuss and show the empirical data collected from the observation, interview and questioner's survey. It's analyzed by Microsoft Excel and SPSS data processing results. On the Questioner survey results the purpose of this questioner to determine what concept the employees have.

5.1.1 The Interview Questions Responses

The interview questions were prepared for the company Manager, Garment Engineer and industrial Engineer based on the lean, waste, work study and other factors focused on the productivity and waste minimization. The response is different according to them work sections more discussed with the Garment Engineer on the production section..

5.1.2 Introduction to Quantitative Data Analysis

The qualitative data were obtained from TIDI and from the case company statistical during the survey time.

The Existing Production of the case Company

The current production of Addis garment sc.co determined by using different data collection systems like questioner, observations, interview and secondary documents.

Table 5.1 Existing Production/day/pcs

	1000/day/pcs	**6000/week/pcs**	**24000/month/pcs**	**288000/annual/pcs**

Table 5.2 .Type of wastes per kg that show in case company

No	Type of wastes	2016 -2017	2017 -2018	Average
1	over production	67	50	58.5
2	Defect frequent errors	39	44	41.5
3	Unnecessary inventory	50	45	47.5
4	Inappropriate processing	21	18	19.5
5	Transportation	15	29	22
6	Waiting time	60	60	60
7	Unnecessary motion	35	33	34

From the above table understand the company defect levels. The waiting time is on the first level over production on the second unnecessary inventory on the third level defect frequent errors on the forth level unnecessary motion on the fifth transportation on the sixth and inappropriate processing on the seventh and last level. This paper focusing on the first level wastes (waiting time) it includes Long periods of inactivity for people, material picking hours and information or goods.

Selection of Key Performance Indicators

Organizations must select metrics that will align business performance to its strategic objectives and vision. Different researchers suggested that companies must keep these metrics very simple and that a reasonable number will about 5-6 metrics.

Perspective	Code	Description
Wastes	W1	Transportation
	W2	Inventory
	W3	Unnecessary motion
	W4	Inappropriate processing
	W5	Over production
	W6	Waiting
	W7	Defects
Customer requirement	CR1	On time delivery
	CR2	Features
	CR3	Customer and market focus
	CR4	Aesthetics
	CR5	Human resource
Continuous improvement	CI1	Lean
	CI2	Kaizen
	CI3	Training
	CI4	Work study
	IT1	Machine failure
	IT2	Material shortage

Idle time	IT3	Power failure
	IT4	Machine setup
	IT5	Labor shortage
	IT6	Material searching

5.2 Questioner survey result

A) Is about the customer requirement in shirt production in Addis Garment sc.co.

5= Excellent, 4= Very good, 3=Good, 2=Fair 1= Poor

Table 5.3 respondents result in percentage

No	Questioners	5	4	3	2	1
CR1	On time delivery	11.25	28.35	16.25	26.25	11.25
CR2	Price	11.25	13.75	25	11.25	38.75
CR3	Design	11.25	35	16.25	26.25	11.25
CR4	Durability	11.25	25	35	17.5	11.25
CR5	Feature	16.25	23.75	11.25	18.75	28.75
CR6	Conformance	11.25	35	16.25	30	7.5
CR7	Aesthetics	11.25	35	16.25	11.25	26.25

On the above table the analysis of the customer requirement result the high result shows the on time delivery, design, durability and features of the shirt

B) The questions about the waste happen on the production section.

5=Excellent , 4= Very good, 3=Good, 2=Fair, 1= Poor

Table 5.4 respondents result in percentage

No	Questioners	5	4	3	2	1
W1	Over production	11.25	23.75	16.25	26.25	22.5
W2	Transportation	11.25	23.75	16.25	18.75	30
W3	Defects	16.25	35	11.25	30	7.5
W4	Inventory	11.25	35	16.25	26.25	11.25
W5	Waiting time	16.25	23.75	11.25	18.75	28.75
W6	Inappropriate process	11.25	35	16.25	30	28.75

W7	Motion	11.25	35	16.25	11.25	26.25

On the company high waste happens because of waiting time and defects.

C) The questions about the idle time on the production section

5=Excellent, 4= Very good, 3=Good, 2=Fair, 1= Poor

Table 5.5 respondent result in percentage

No	Questioners	5	4	3	2	1
IT1	Machine failure	11.25	35	16.25	26.25	10
IT2	Material shortage	11.25	40	16.25	21.25	7.5
IT3	Power failure	11.25	35	16.25	13.75	11.25
IT4	Machine setup	12.5	23.75	27.5	15	22.5
IT5	Labor shortage	11.25	23.75	16.25	26	22.5
IT6	Material searching	23.75	35	16.25	22.5	11.25

As we see on the above table most of the company wasting time happens because of material searching.

D) The questions about the continuous improvement

5=Excellent, 4= Very good, 3=Good, 2=Fair, 1= Poor

Table 5.6 respondent result in percentage

No	Questioners	5	4	3	2	1
CI1	Lean	25	23.75	10	21.25	20
CI2	TQM	16.25	22.5	27.5	22.5	11.25
CI3	Kaizen	22.5	32.5	23.75	21.25	0
CI4	Training	15	32.5	22.5	18.75	10
CI5	Work study	11.25	23.75	16.25	30	18.75

As we see on the above questioner result lean have a big factor on the continuous improvement of the production section.

5.3 Result and Discussion

Correlation Analysis

Correlation is a bivariate analysis that measures the strength of association between two variables. The strength of relationship, the value of the correlation coefficient varies between

+1 and -1. +ve indicates a perfect degree of association between two variables, if its 0 the relationship is weaker -ve sign shows negative relationship. Measures how the factors or the variables are linked each other. By using SPSS software tools. In the SPSS data entry module the analysis will shown as Pearson Correlation (r) and significance (p) value of the two variables therefore, it will be vital to remind the properties and interpretation of r value (or Pearson Correlation).

- The value of Pearson Correlation (r) is between -1 and +1. That indicates the extent to which two variables are linearly related.
- Correlations never lower than -1.
- Never higher than r=1.if 1 they are perfectly positive, and – ve the reverse.

($r < 0.1$ weak, $r < 0.3$ modest, $r < 0.5$ moderate, $r < 0.8$ strong, $r \geq 0.8$ very strong).

- This questioner has 3 main sections of and total around 23 questions all this section in order to see the correlations of the factors.

And the P value $< = 0.05$, ($p > 0.5$), then the correlation is not significant.

Table correlation between customer requirement variables

5.2.1 Analysis of customer requirement variables

Table 5.3 Analysis of Customer Requirement variables

Correlations[c]

		on time delivery	price	design	durability	feature	Conformance	Aesthetics
on time delivery	Pearson Correlation	1	.453**	1.000**	.879**	1.000**	-.466**	.442**
	Sig. (2-tailed)		.000	.000	.000	.000	.000	.000
Price	Pearson Correlation	-.453**	1	-.453**	-.355**	-.453**	.278*	-.379**
	Sig. (2-tailed)	.000		.000	.001	.000	.012	.001
Design	Pearson Correlation	1.000**	.453**	1	.879**	1.000**	-.466**	.442**
	Sig. (2-tailed)	.000	.000		.000	.000	.000	.000
Durability	Pearson Correlation	.879**	.355**	.879**	1	.879**	-.583**	.421**
	Sig. (2-tailed)	.000	.001	.000		.000	.000	.000
Feature	Pearson Correlation	1.000**	.453**	1.000**	.879**	1	-.466**	.442**
	Sig. (2-tailed)	.000	.000	.000	.000		.000	.000
Conformance	Pearson Correlation	-.466**	.278*	-.466**	-.583**	-.466**	1	-.482**
	Sig. (2-tailed)	.000	.012	.000	.000	.000		.000
Aesthetics	Pearson Correlation	.442**	.379**	.442**	.421**	.442**	-.482**	1
	Sig. (2-tailed)	.000	.001	.000	.000	.000	.000	

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

c. Listwise N=80

According to Pearson correlation(r value) when we see the above relationship of each variables in customer requirement they have strong relation with significance level of 0.05 and the causal Pearson Correlation of variable of customer requirement on time delivery Vs aesthetics their value is 0.442 which shows moderate relationship it means customers

satisfaction may not came due to aesthetics of the shirt. For the company and the highest Pearson correlation in customer perspective is between durability and features it mean that they are the highest factor for customer satisfaction analysis.

5.2.2 Analysis of Idle time variables

Table 5.4 Analysis of Idle time variables

Correlations[b]

		machine failure	power failure	material shortage	machine setup	labour shortage	material searching
machine failure	Pearson Correlation	1	.531**	.349**	1.000**	.747**	.896**
	Sig. (2-tailed)		.000	.002	.000	.000	.000
power failure	Pearson Correlation	.531**	1	.622**	.531**	.743**	.473**
	Sig. (2-tailed)	.000		.000	.000	.000	.000
material shortage	Pearson Correlation	.349**	.622**	1	.349**	.806**	.611**
	Sig. (2-tailed)	.002	.000		.002	.000	.000
machine setup	Pearson Correlation	1.000**	.531**	.349**	1	.747**	.896**
	Sig. (2-tailed)	.000	.000	.002		.000	.000
labour shortage	Pearson Correlation	.747**	.743**	.806**	.747**	1	.887**
	Sig. (2-tailed)	.000	.000	.000	.000		.000
material searching	Pearson Correlation	.896**	.473**	.611**	.896**	.887**	1
	Sig. (2-tailed)	.000	.000	.000	.000	.000	

**. Correlation is significant at the 0.01 level (2-tailed).

b. Listwise N=80

On this relation relationship of each idle time variables they have strong relation with significance level of 0.05 and the causal Pearson Correlation of variable of idle time on machine failure Vs material searching their value is 0.896 which shows very strong relationship it means idle time may came due to material searching. For the company and the

highest Pearson correlation in customer Perspective is this idle time happen by material searching.

5.2.3 Analysis of waste in production variables

Table 5.5 Analysis of Waste in Production variables

Correlations[b]

		over production	transportation	defects	inventory	material searching	labour shortage	machine setup
over production	Pearson Correlation	1	.577**	.541**	.496**	.701**	.386**	.396**
	Sig. (2-tailed)		.000	.000	.000	.000	.000	.000
Transportation	Pearson Correlation	.691**	1	.389**	.338**	.700**	.637**	.638**
	Sig. (2-tailed)	.000		.000	.000	.000	.000	.000
Defects	Pearson Correlation	.370**	.377**	1	.534**	.675**	.450**	.734**
	Sig. (2-tailed)	.000	.000		.000	.000	.000	.000
Inventory	Pearson Correlation	.1.000**	.691**	.370**	1	.370**	.691**	1.000**
	Sig. (2-tailed)	.000	.000	.000		.000	.000	.000
Waiting time	Pearson Correlation	.734**	.450**	.675**	.534**	1	.377**	.370**
	Sig. (2-tailed)	.000	.000	.000	.000		.000	.000
Inappropriate processing	Pearson Correlation	.638**	.637**	.700**	.338**	.389**	1	.691**
	Sig. (2-tailed)	.000	.000	.000	.000	.000		.000
Unnecessary motion	Pearson Correlation	.396**	.386**	.701*	.496**	.541**	.577**	1
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000	

**. Correlation is significant at the 0.01 level (2-tailed).

On this relation relationship of each waste variables they have strong relation with significance level of 0.05 and the causal Pearson Correlation of variable waste on overproduction Vs excessive motion their value is 0.396 which shows very weak relationship it waste in production may not come due to excessive motion . For the company and the highest Pearson correlation in customer perspective is this waste in production due to waiting time.

5.2.4 Analysis of continuous improvement variables

Table 5.6 Analysis of Continuous Improvement variables

Correlations[c]

		lean	TQM	Kaizen	training	work study
Lean	Pearson Correlation	1	-.809**	.122	.496**	.245*
	Sig. (2-tailed)		.000	.280	.000	.028
Kaizen	Pearson Correlation	.122	-.063	1	.445**	.411**
	Sig. (2-tailed)	.280	.582		.000	.000
Training	Pearson Correlation	.496**	-.195	.445**	1	.371**
	Sig. (2-tailed)	.000	.084	.000		.001
work study	Pearson Correlation	.245*	-.320**	.411**	.371**	1
	Sig. (2-tailed)	.028	.004	.000	.001	

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

c. Listwise N=80

On this relation relationship of each waste variable they have strong relation with significance level of 0.05 and the causal Pearson Correlation of variable continuous improvement on lean Vs work study.

5.4 Introduction to Quantitative Data Analysis

This data obtained from the observation, interview of the employees and manager to know the factors that affect the productivity.

5.4.1 Define the Process

Addis Garment sc.co (Augusta) has different departments administrative, accountants, marketing and others. In the production section there are quality manager, design room,

spreading room, ironing and other sections. Among these shirt production process is major one. Company Production process consist sub process.

5.4.2 Function of each Process

1. Design; - In this section the main operation is taking out designs according to the customer orders. Designed and the dimensions are transferred to patterns. Adjustments are made for size differences and stylistic preferences.

2. Cutting; - the t-shirt sections are cut to the dimensions of the patterns. The pieces consist of a tubes body or separate front and back sections, sleeves, perhaps pocket and trim.

3. Assembling /stitching; - in this section stitching all the separated fabrics by using stitching machines. All as its own parts (front side, back side, pocket, collar and other parts)

Trimming: useful to remove the unnecessary parts (threads or fabrics) of the edge of the shirts.

4. Label setting; - attached at the back of the neckline. It provides information about the manufacturer, size, fabric content, washing instructions.

5. Ironing; - on the finishing section the shirt will be ironed for holding the shape of the last and having good structures.

5.4.3 Factors Affecting the Productivity

As we see on the above literature part factors affecting productivity in textile industry as Mohmood (2015) there are four factors internal factors, external factors, own factors and foreign factors. According to Mazharul Islam Kiron (2014) the affecting factors are product factors, plant and equipment factors, technology factors and material and energy factors.

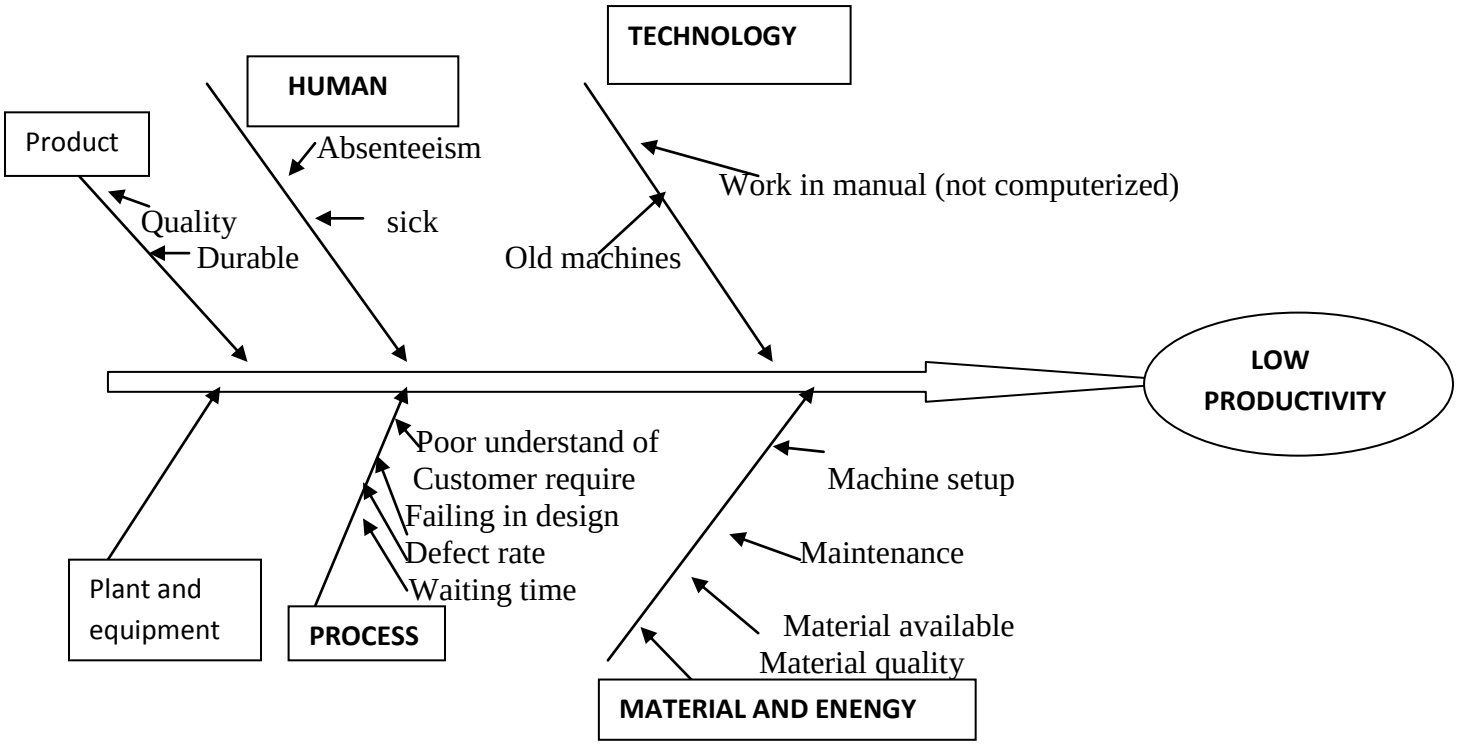


Figure 5.1. Low Productivity factors fish bone diagram

5.4.5 Preparation to observe the time of each element takes

A. Makes ready the stationeries like time study format, stop watch (digital one) and pencil and got overall information's about the operators and processes.

B. Have selected the Shirt operation to conduct our study (because the case company produces only men shirts)

- It has a long sleeve with a cuff.
- The color of shirt is called a blue.
- The shirt has a back yoke.
- It has a plain fabric structure.
- It has a pouch pocket without flap.
- The placket is self folded
- It has a nine button

C. Inform the operators that we are going to measure time for her/his operation.

D. The operations been carefully observed through the flow chart of the processes and broke down operations into elements.

5.4.6 Time capturing Analysis:

The time taken for completing each elements of the operation cycle by the operator is measured time is captured in seconds. The element timing is performed for consecutive 8 operation cycles. The stop watch and later the element timing are calculated. Any abnormal times didn't appear and will not record during the time study. Abnormal time may be occurred due to bobbin change, thread break, power cut or quality issues.

Required sample size = n = $(\frac{zs}{h\bar{x}})^2$

h= accuracy level (acceptable error) desired in percent of the job element expressed as a decimal

(5 %= 0.05)

z = number of standard deviations required for desired level of confidence (90% confidence =1.65)

s= standard deviation of the initial sample

$\bar{x}$ = mean of the initial sample

n= required sample size

In the reading the time is taken for each element in all eight cycles. The summations of times of eight cycles for each element are averaged to find the average element time called Basic Time.

Average observed time = **Sum of the times recorded to perform each element**

Number of observations

Table 5.10. Observed time of each element in sec

Operation elements	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**total**	**Average**
Collar										
Collar band hem	20	23	23	28	23	22	22	23	184	23

Collar run stitch	36	33	33	34	37	36	34	34	277	35
Collar top stitch	30	31	31	35	31	33	33	30	254	32
Collar turning and blocking	26	23	26	25	25	24	24	22	195	24
Collar band attach	43	42	41	45	45	43	42	41	342	43
Collar band top stitch	25	26	24	25	25	26	22	27	200	25
Collar peak iron	21	23	25	24	26	25	24	25	193	24
Cuff										
Cuff hem	30	28	26	33	34	25	37	35	248	31
Cuff run stitch	41	40	38	35	43	30	43	45	315	39
Cuff trimming	28	23	28	25	30	31	31	30	226	28
Cuff top stitch	38	40	41	41	40	43	41	41	324	41
Cuff press	23	18	20	21	21	22	22	21	168	21
Front section										
Pocket marking	15	13	18	15	15	13	17	17	123	15
Pocket Hem	23	20	19	20	23	17	24	18	164	21
Pocket iron	33	30	33	33	30	30	34	26	249	31
L& R iron	37	33	36	31	28	33	35	34	267	33
Left front Placket	39	37	37	38	39	39	36	39	304	38
Right front Placket	35	33	36	33	30	36	37	33	273	34
Back										
Back yoke run stitch	33	30	35	31	31	33	34	35	262	33
Back yoke top stitch	31	28	29	29	27	29	26	33	232	29
Sleeve section										
Set sleeve box	68	70	75	65	63	70	66	67	544	68
Insert sleeve placket	25	20	27	21	21	28	23	20	185	23
Assembly										
Shoulder attach	26	24	26	26	23	24	26	26	201	25

Shoulder top stitch	25	20	17	25	25	24	26	20	182	23
Sleeve set	70	60	65	65	68	75	60	68	531	66
Sleeve Sh. Out line	65	70	70	73	60	63	65	65	531	66
Side seam	65	63	70	73	75	75	70	70	561	70
Cuff set	66	60	58	70	71	72	60	60	517	65
Collar set	55	53	47	56	53	54	58	49	425	53
Collar close	60	60	56	59	59	61	63	59	477	60
Bottom Hem	65	63	67	62	64	60	66	67	514	64
Button Hole	60	69	61	70	65	62	69	59	515	64
Button Attach	56	61	61	63	57	61	59	58	476	60

Determine the Performance Rating

I, Rating

It is a subjective comparison of any condition or activity to a benchmark, based upon our experience. While the mechanics of time study record the time a task did take, applying a rating will determine the time a task should take. Generally it is a technique used to assess the speed, effort and effectiveness of the operator on the specific operation.

A, 100% performance or Normal Performance

The concept of 100% performance is a critical element of time study and performance measures.

Normal performance is the rate of output which qualified workers will achieves without over exertion over the working day shifts provided they know and adhere to the specified method and provided they are motivated to apply themselves to the work. This performance is denoted as 100% on standard rating and performance scales.

B, Slower Performance

A slower performance rate is, for a worker which produces fewer pieces per hour, recorded as a percentage below 100% or Normal Performance.

C, Faster Performance

A faster performance rate that produces more pieces per hour is recorded as greater than 100%.

II, Characters considered for 100% Performance or Normal operator

An operator who can perform as per the following points considered as the normal operator in this study.

•Fluid motions without hesitation •No false starts or duplications

•Consistent, coordinated, effective •No wasted actions or work

•Attention centered on the task and less responsive to irrespective movement in the company

III, Accuracy of rating

The tasks did to improve our accuracy of rating an operator, are

- Understand as much as possible the operation and the standard operating procedures for the shirt,
- Concentrate on operator motions while recording,
- Eliminate or ignore interruption or events not in the operator's control.
- Avoid a corrupting bias when observing fast and slow operators in succession and increase the number of cycles observed.

5.4.7 The Observed Rating in the Company

The factory has operators with different level of speed, effort and effectiveness of the specific operations according to the principles of the performance rating mentioned above. Here it is appropriate to use 85%, 95% and 100% for their performance on specific operation.

5.4.8 Normal Time

Normal Time = Observed Time *Rating

5.4.9 Allowances

1. Relaxation allowance;-Personal needs allowance is (from 5 to 7% of basic time) and Basic fatigue is (4 % of basic time). Generally taken to be 11%

2. Contingency Allowances; - (5 %)

3. Special Allowances; - (10 %)

5.5 Calculation of Standard time and Data Analysis

To convert basic time to normal first have to multiply it with operator performance rating. Here for example, rating has been taken 100%. Now add the allowances for machine

allowances, fatigue and personal needs etc. Add machine allowance only to those elements where machine is running and fatigue and personal needs to all elements. Now got standard time for each element in seconds. Sum up all elemental time and convert seconds into minutes. This is standard minutes or SAM.

Standard Time = Total normal time

1 - Allowance factor

Table 5.12. Recorded Data's and Developed Standard Time

Operation elements	1	2	3	4	5	6	7	8	TOTOAL	AVERAGE	RATNG	CONTUGENCY ALLOWANCE	PERSONAL&FATIG ALLOWANCE	OTHER ALLOWANCE	TOTAL ALOWANCE	NORMAL TIME	SAM
Collar																	
Collar band hem	20	23	23	28	23	22	22	23	184	23	0.85	0.03	0.11	0.05	0.19	19.55	24.14
Collar run stitch	36	33	33	34	37	36	34	34	277	35	0.85	0.03	0.11	0.05	0.19	29.43	36.33
Collar top stitch	30	31	31	35	31	33	33	30	254	32	0.85	0.03	0.11	0.05	0.19	26.99	33.32
Collar turning & blocking	26	23	26	25	25	24	24	22	195	24	0.85	0.03	0.11	0.05	0.19	20.72	25.58
Collar band attach	43	42	41	45	45	43	42	41	342	43	0.85	0.03	0.11	0.05	0.19	36.34	44.86
Collar band top stitch	25	26	24	25	25	26	22	27	200	25	0.85	0.03	0.11	0.05	0.19	21.25	26.23
Collar peak iron	21	23	25	24	26	25	24	25	193	24	0.85	0.03	0.11	0.05	0.19	20.51	25.32
Cuff																	
Cuff hem	30	28	26	33	34	25	37	35	248	31	0.85	0.03	0.11	0.05	0.19	29.54	36.36
Cuff run stitch	41	40	38	35	43	30	43	45	315	39	0.85	0.03	0.11	0.05	0.19	34.47	41.32
Cuff trimming	28	23	28	25	30	31	31	30	226	28	0.85	0.03	0.11	0.05	0.19	24.01	29.65
Cuff top stitch	38	40	41	41	39	43	41	41	324	41	0.85	0.03	0.11	0.05	0.19	38.48	47.50
Cuff press	23	18	20	21	21	22	22	21	168	21	0.85	0.03	0.11	0.05	0.19	17.85	22.04
Front section																	
Pocket marking	15	13	18	15	15	13	17	17	123	15	0.85	0.03	0.11	0.05	0.19	14.61	18.03
Pocket hem	23	20	19	20	23	17	24	18	164	21	0.85	0.03	0.11	0.05	0.19	19.48	24.04
Pocket iron	33	30	33	33	30	30	34	26	249	31	0.85	0.03	0.11	0.05	0.19	26.46	32.66
L&R iron	37	33	36	31	28	33	35	34	267	33	0.85	0.03	0.11	0.05	0.19	28.37	35.02
Left front placket	39	37	37	38	39	39	36	39	304	38	0.85	0.03	0.11	0.05	0.19	36.1	44.57

Right front placket	35	33	36	33	30	36	37	33	273	34	0.85	0.03	0.11	0.05	0.19	32.42	40.02
Back																	
Back yoke run stitch	33	30	35	31	31	33	34	35	262	33	0.85	0.03	0.11	0.05	0.19	27.84	34.37
Back yoke top stitch	31	28	29	27	29	29	26	33	232	29	0.85	0.03	0.11	0.05	0.19	24.65	30.43
Sleeve section																	
Set sleeve box	68	70	75	65	63	70	66	67	544	68	0.85	0.03	0.11	0.05	0.19	64.6	79.75
Insert sleeve placket	25	20	27	21	21	28	23	21	185	23	0.85	0.03	0.11	0.05	0.19	18.5	22.84
Assembly																	
Shoulder attach	26	24	26	26	23	24	26	26	201	25	0.85	0.03	0.11	0.05	0.19	26.38	32.57
Shoulder top stitch	25	20	17	25	25	24	26	20	182	23	0.85	0.03	0.11	0.05	0.19	23.89	29.49
Sleeve set	70	60	65	65	68	75	60	68	531	66	0.85	0.03	0.11	0.05	0.19	69.69	86.04
Sleeve sh.out line	65	70	70	73	60	63	65	65	531	66	0.85	0.03	0.11	0.05	0.19	69.69	86.04
Side seam	65	63	70	73	75	75	70	70	561	70	0.85	0.03	0.11	0.05	0.19	73.63	90.90
Cuff set	66	60	58	70	71	72	60	60	517	65	0.85	0.03	0.11	0.05	0.19	67.86	83.77
Collar set	55	53	47	56	53	54	58	49	425	53	0.85	0.03	0.11	0.05	0.19	50.47	62.31
Collar close	60	60	56	59	59	61	63	59	477	60	0.85	0.03	0.11	0.05	0.19	56.64	69.93
Bottom hem	65	63	67	62	64	60	66	67	514	64	0.85	0.03	0.11	0.05	0.19	61.04	75.35
Button hole	60	69	61	70	65	62	69	59	515	64	0.85	0.03	0.11	0.05	0.19	61.16	75.50
Button attach	56	61	61	63	57	61	59	56	476	60	0.85	0.03	0.11	0.05	0.19	56.53	69.78
																Total = 1516.08	

SMV or SAM; - Standard Minute Value term is used in the field of industrial Engineering. SMV defined as “Time taken by a standard worker to perform the task with pre-defined conditions" SMV = Basic Time + Allowances (bundle allowance + machine or personal allowance).

Standard time of each operation in men’s long sleeve shirts = total time per garment is 15.22 minutes (Balakumar, 2002).

The total Established standard time of the case company is = 25.3 minutes

As the result of the time Study application in the production of shirt, the SAM of the shirt becomes 25.3 minutes. But the SMV standard for the shirts production is 15.22 so, from the case company SMV it have 10.08 minute differences. According to the five days (2 in the

morning and three in the afternoon) observations by recording every wasting time due to the various reasons like material picking, machine stoppage, and other reasons. the total attended time by operators on work is 360 minutes out of the total time which is 480 minutes per day. So the company's overall efficiency is appears to be 75%.

The company has 302 direct workers which mean it will have 144,960 minutes per day. So that since the SAM of shirt is 25.3 minutes it is expected to produce 5730 pcs per day with the efficiency of 75%. However its actual production per day is averaged to 1000 - 1200pcs. This tells us that the company's production process has time waste in the production.

5.6 Waiting

On the literature waiting is any idleness that occurred on the work area that can delay the productivity and making high the time waste rate. That can happen because of machines, operator's problems, materials picking hours and other causes. This idleness one cause can influences the others. Then the productivity becomes low rate.

Table 5.13…. downtime (source; planning and control department, 2017/2018 annual report of the company)

Section	Machine failure(Hr)	Material shortage (Hr)	Power failure (Hr)	Machine setup (Hr)	Labor shortage (Hr)	Material picking (Hr)	Total(Hr)	Available time(Hr)	Production loss (pcs)
Cutting	10.3	5	2	3	5	10	35.3	2496	13496
Stitching	14	8	5.8	21	10	25.1	83.9	2496	22942
Finishing	22	3	1.8	17	2.1	15	60.9	2496	10300
Total	46.3	16	9.6	41	17.1	50.1	190.1	7488	46738

As we see on the above table data of annual report table the material picking hours is higher than the other defect causes.

Down time = total down time / total working time

190.1 / 7488 *100 = 2.538

Down time for cutting = 35.3 / 2496 *100 = 1.414min

Down time for stitching = 83.9 / 2496 *100 =3.361min

Down time for finishing =60.9 /2496 *100 = 2.439 min

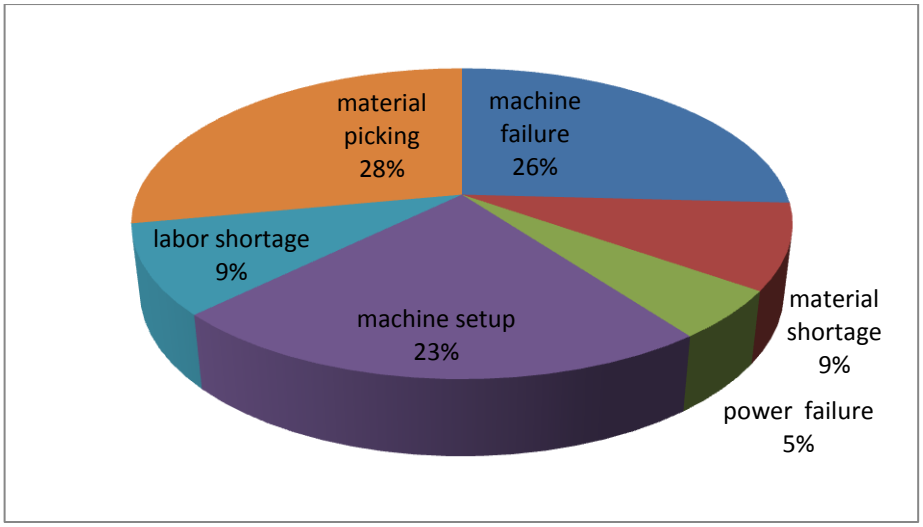


Figure 5.2 Sources of down time

On figure waiting due to material picking take higher proportion because the essential materials are not separated from the non essential, the materials not setting in order and the work place is not clean up and not easy to check for opportunities to improve.

On the above the company waiting time have high proportion on the material picking so for this the cause is the company have not continuous schedule for the cleaning and maintaining because of this the work place are not clean and the essential materials are not separated from the non essentials it mean not sitting in order. Because of those reasons the operators take time to find the materials what they need.

CHAPTER SIX

Proposed Continuous Productivity Improvement Model

6.1 Introduction

Productivity measurement and improvement goes hand in hand, because one cannot improve what one cannot measure. Improving productivity is one major strategy for competitive with others. To improve productivity there are lots of methods but integrated models are more preferable because one answer the other questions. For instance Highlight problems of interest, Economical experimentation, Precision of thought , Solving operational problems , quantifies relationships and identifies gaps in our knowledge (can be used to guide research) , range of variables that can be examined in actual system is often quite small in time and space scale and dynamics of actual system may preclude data collection and observation.

6.1.1 Model Development Criteria

To develop a model, it must fulfill some criteria's according to the literature and the case company problems the developed model be easily understandable, addressing the main problems of the company, have continuity for the continuous improvement of the production, easily can to apply for all workers on the company and it must involve all the workers from the top level up to the low level workers. It must be acceptable to the departmental staff and workers. It must meet all their practical requirements and technical specifications. The model constructed mainly based on method study concept but on each step the lean 6s concepts are added to bring the desired objective of the model to be developed.

1. Preparation: giving awareness from to top management up to low level workers, team formation, giving training.

2. Select: consist selection of work (process), describe function and goal and identify factors, indicators.

3. Record: record the overall data about the all process and the flow (present method to limit of detail economically justified).

4. Examine: measure the time study to find the real wastes of the shirt production (the fact critically considering).

5. Develop: develop method under prevailing circumstances**. (**Develop the lean 6 s procedures to identify the intervention option improvement).

6s; - Sort; - eliminate what is not needed (separate the essential from the non essential).

Set in order; - organize what remains (a place for everything and everything in its place).

Shine; - clean work area (clean up the work places and check for opportunities to improve).

Standardize; - schedule cleaning and maintaining (ensures we don't do what we always did).

Sustain; - make 6s as a way of life (make the other part of everyday life to maintain improvement).

Safety; - create a safe and healthy work environments.

6. Install: implement improved solution by using the necessary resource.

7. Maintain: check whether the developed model is working or not (validation testing).

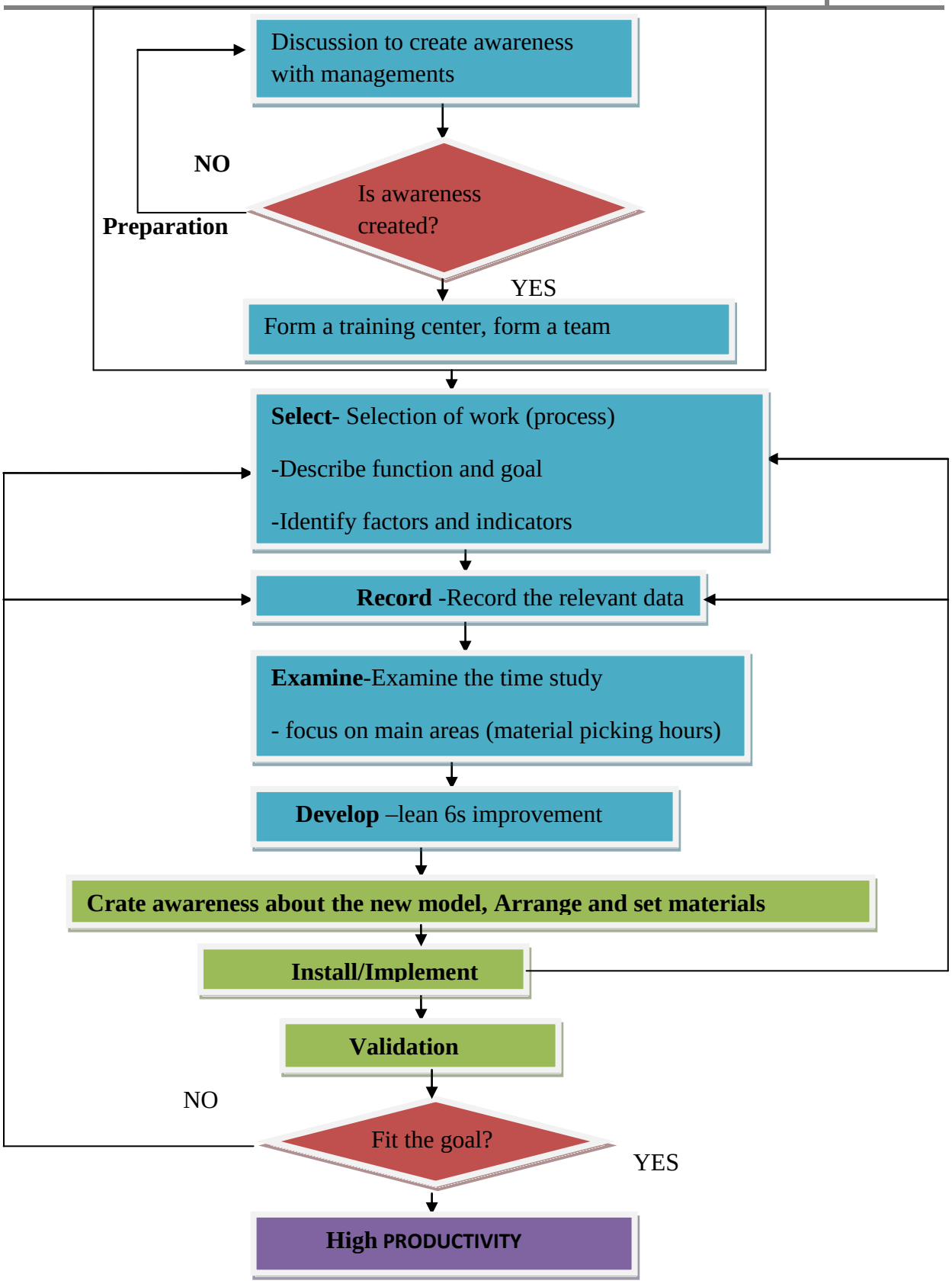

Discussion to create awareness with managements
NO
Is awareness created?
Preparation
YES
Form a training center, form a team
Select- Selection of work (process)
-Describe function and goal
-Identify factors and indicators
Record -Record the relevant data
Examine-Examine the time study
- focus on main areas (material picking hours)
Develop –lean 6s improvement
Crate awareness about the new model, Arrange and set materials
Install/Implement
Validation
NO
Fit the goal?
YES
High PRODUCTIVITY

Figure 6.1.Propose model the integration of work study and lean (6s)

6.1 Detail of the proposed model

6.1.1 Preparation;-

A. Awareness creation for managements

Managements are the main part of the company. without them awareness it's not easy to work on the employee, First discuss with the top managers about the problems and giving awareness about the new integrated ideas (work study with lean) and its benefits on the production. Up to they are accepted.

B .Create a training center; -

Create a center to start a continuous training specifically train the production line employees. By schedule because training needs continuity.

C. Form a team;-

Giving awareness about the team work benefits then form a team on them departments. The team is responsible to the management and performs different activities such as establishing sub teams, planning schedules for regular meeting, conducting training to employee regularly, controlling activities, prepare awards for those who show greater achievement.

D. Give training for the employees

Give a continuity training start from the managing staff to share ideas from the management up to the employees and to increase and improve the staff communications. Train the work process in detail and how to improve productivities by decreases wastes, deeply about the new model.

6.1.2 Select (Define); -

Define in which area did most wastes happen? When and where down time occurs carefully look, it must also include the selection of the appropriate techniques to achieve the end result, Describe function and goal, Identify factors and indicators.

6.2.3. Record; -

The existing system must be collected before discarding the method or procedure. This is to ensure an objective record of the way the job is carried out is maintained. The records are based on the title and those who can help to achieve the goal. From lean tools used takt time, 6s, from work study separately work measurement tools to record the time study and method study procedures to solve the problems)

This record is based on direct observation and interview with the managers and workers.

- ✓ Record the time study by stop watch.
- ✓ Record the operator's performance.
- ✓ Record the description of how the job is done.
- ✓ Record how much they produce
- ✓ Record the procedure of the productions.
- ✓ Record the time of workers movement for material searching.

6.2.4 Examine;-

Examine the time study data by using different calculations. Then analysis by diagrams and graphs like cause and effect diagrams and pie charts….

Required sample size = n = $(\frac{zs}{hx})^2$ know the sample size how many workers have and how to implement the model,

Average observed time = $\frac{\text{Sum of the times recorded to perform each element}}{\text{Number of observations}}$

To study the time study knows the average observed time. It helps to know in which area the waste occurred.

Normal time= observed time * Rating

Standard time = total normal time

2-Allowance factor

To compare the current working time with the standard and to compare the current working time with the standard and to proof is there time waste or not.

SMV= basic time + allowance

Down time = total down time * 100

Total working time

Productivity = output , by the ratio of output and input to know the productivity.

Input

6.2.5 Develop

According to the data analysis of the case company the time wastes coming from the material picking hours have high value by the integration of lean 6s tools with the method study procedures the wastes can be solved (material searching, machine failure ,material shortage, power failure ,machine setup and labor shortage.

Lean 6s tools are selected because the company have high level of waste is material picking (material searching) so, for this material picking (searching) time wastes 6s methods are preferable because 6s is a methodical method to improve the housekeeping and standardize the process making them more efficient and less stressful for the employees, fewer accidents, high level of quality and production and fewer breakdowns.

- Sort; - separate the essential from non essential materials, the cutting department materials separated from the stitching and finishing departments others also then eliminate what is not needed.
- Set in order; - organize the essential ones and give specific places or orders (shelves) for every material (needles, scissors, threads, fabrics, belt, gear…) to minimize the employee's movement and stress.
- Sustain; - make this 6s principles as a good way of improvements.

- Shine; - make the working place clean every time even to reduce accidents.
- Standardize;-giving a common color codes and way of working
  - set up continues maintenance and cleaning schedules
  - Conduct regular manufacturing equipments
  - Upgrade manufacturing equipments
  - Create a new technology plan for the manufacturing.
- Safety; - removing any hazardous thing then create a safe and attractive working environments.

6.2.6 Install/Implement

Before installation give awareness how to install, what materials need….To install this integrated model all the employees start from the top management have the awareness of the integrated model idea and the benefit for the improvement of productivity.

After this model applicable all the workers start from the top managements up to floor level must be committed for the rules and regulations and be Volunteer for the training, participate for all team works and for all what the new models need.

6.2.7 Maintain/validation

Check the validity of the new applicable model, is it reduce the material picking hour, machine failure hour, material shortage hour and machine setup hours. if its fulfill the goal its nice if not turn back to the first procedures record or select based on the problems.

6.2 Advantage of the new integrated model;-

To Reduce non value added activities, to Improve working environments by preparing a suitable and redesign of adjustable working tables, shelves for material setting, 6s implementation will solve work organization problems through introduction of continuous improvement, To increase the Labor productivity by improved through continuous skill development by giving continuous training and Having continuous meeting with the workers to know them suggestions and idea on the working flows. Finally by reducing waste time improve the productivity.

6.3 Proposed model Validation;-

Engineering Mathematical analysis Method for productivity rate (To validate the new model).Productivity rate (Q) or production rate is one of the important indicator criteria to improve the system and output in production mathematical and statistical analysis is required to be applied for productivity rate in industry over view of the failure factors (Tan Chan Sin, Nov 2014).

Productivity= $\frac{output\ finished}{input\ variables}$

The variables of input and output can be specified and adjusted with different variables. Now more on the time used and output of products since both of these variables are affected by the technical or technological factors of production line (Quan and H. Kasami, 2008).

Productivity rate (Q) =$\frac{number\ of\ parts(Z)}{time\ used(\theta)}$

(Q) = no of parts produced,(Z) parts,(θ) which produce the yield of Q parts/minute or parts/hour.

(Qa.f.r) =average level failure rate of workstation

tmo= total machine time, ta=auxiliary time, q total number of serial station, mr= time to repairing time ,λs.i =average failure rste per station in flow line. ,λc= failure rate in control system and λw= failure rate of waste, λit= failure rate in idle time

Productivity rate Qa.f.r = $1/(\frac{tmo}{q} + ta)[1 + mr(q\lambda s.i + \lambda w + \lambda it)]$

Qa.f.r develops due to consideration of several important parameters which are different workstation failure rate with theory of probability.

Actual production rate is Qac=Z/θ = 125/hr/8 =0.260/min

Productivity rate with average station failure rate=

$$\text{Qa.f.r} = 1/(\frac{tmo}{q} + ta)[1 + mr(q\lambda s.i + \lambda w + \lambda it)]$$

=0.449 products/min

Productivity rate with different station failure rate is

$$\text{Qd.f.r} = 1/(\frac{tmo}{q} + fm + ta)[1 + mr(\sum i = 1\ \lambda s.i + \lambda w + \lambda it)]$$

= 0.2420 products/min

Percentage error for Q d.f.r with Qac = 0.2420 – 0.260 /0.260 * 100% = 6.9 %

Percentage error for Q a.f.r with Qac = 0.449 -0.260/0.260*100% = 72.6%

From the productivity rate result and which is actual productivity rate is used as guideline to check this model can provide more accurate result. Regarding the result it presents the percentage error when compared to actual productivity rate result. Productivity rate with average station failure rate Q d.f.r is just 6.9% of percentage error while productivity rate with average station failure rate Q a.f.r obtained is 72.6% of percentage error when compared to actual productivity rate Q ac. The reason Q d.f.r is not exactly same to actual is due to unexpected factors that occurred in line.

Hence, it is proven and validates the model of productivity rate with different station failure rate yields the most accurate result which is less than 10% error when compared to the actual result.

CHAPTER SEVEN

Conclusion and Recommendation

7.1 Conclusion

Productivity improvement is an important issue in textile and garment industry. The profit earning of textile and garment products industry largely depends on productivity improvement. Good quality in the production can increase the value of a product or services, establishes a brand name and build up good reputation, for customer satisfaction and high sales. Based on the research documentation through all chapters conclude many things. This study shows the way of finding gap of production process and operations. By implementing work study, method study (work measurement) and lean wastes. The objective of this paper is to assess the current manufacturing conditions of the Addis garment sc.co (Augusta), to identify factors that affect the productivity of the factory and their indicator, to identify the intervention area for continuous productivity improvement and to develop model for the continuous productivity improvement by the integration of lean and work study. In this paper, relying many papers, literature and direct time conduct for the time study technique knows there is a time waste that reduces the productivity, then again by taking some data this time waste happens because of the employees spent lots of time on the material picking or material searching.

Questionnaire form was then designed to collect data from case company by Four performance perspectives were identified to assess measurement system of the organization 22 key performance indicators was selected based on the correlation having strong 'r' value.

The integrated new model follows the method study procedures preparation giving awareness for the managements and creates a training center then form a team and giving training, By the training around 10% of productivity increase, then select in which area of the case company have high delay by the data know it’s on the stitching departments because of material searching then after record and examine the data here apply lean 6s to be more preferable to reducing waste, increasing productivity and clear visibility of nonconformance at work place. On the 6s procedures separate the materials remove the unwanted then set in

order the wanted materials the employee to get easily. Shine can give pleasant working environment can increase productivity up to 15%. And inline quality inspection at regular interval to decrease defect and to alert the operators in concentrating their job but the managers must be committed for this continuous improvement plan.

However, the overall picture of the result obtained from implementing the above model suggested that productivity improvement by implementing the techniques is particularly sensitive to the effect of workplace safety and worker performance at the workplace

Finally, concluded by the analysis part proof the performance indicators are how related with the productivity and time waste reduction. But because of limited time and the process need continuity couldn't applicable to see the change practically. Other researcher can continue or I will on the other time of researching.

7.2 Recommendation

Based on the above conclusion some recommendations are proposed for consideration by Addis Garment sc.co (Augusta), and researchers.

- Addis garment sc.co plc has problems with productivity. Therefore, The Company will be beneficiary by implementing this model because it touches all the company problems and try to show some corrective ideas and the integrated model mainly focus on the quality and productivity incremental.
- While implementing the method, it needs input data that is related to candidate techniques and production work place budget, installation time and implementation funds. Activities to be done by the all workers together start from top up to labors has to be committed for the team work, training and other company issues.

7.3 Future study area

This study focus on Addis garment (Augusta) p.l.c but that it is advantageous implement to see the impact in other factories.

Identifying other productivity indicators which are not looking in this study, implementing the new integrated model on other operational and production area of the factory.

The research made till now has to be tested either implemented properly or not. If the researches done are not implemented they should be implemented by testing the feasibility of all the research made by so many scholars until today and setting rules how to implement the study then check the validity in practical.

References

Mücella G. Güner, C. Ü. (2001). line balancing in the apparel industry;university of delhi vol 1

A.Adem. (2007). work measurement new principles and proceduers;university of newyork.vol-3

Abruzzi, A. (1952). Work Measurement New Principles and Procedures. European journal of operational resarch :. Vol 2

Adam, A. (1952). work measurement new principles and procedures. new york. Journal of Industrial Engineering", pp. 18-25, 1952.

Antony, J. (2010). Reflective practice' lean vs six sigma. National University of Singapore. Vol 1 (Changiz, 2011)

Bahadir, S. K. (2011). line balancing in garment production by simulation. University of new york,vol 2

Bartholomew, D. (2015).Maximizing People Systems in a Lean Transformation.university of california vol 2.pp 35-42.

M. A. a. G. K. (PhD), "comparative analysis of Ethiopian textile competitiveness: the quality dimension of manufacturing," *International journal of scientfic & engineering research* , vol. 4, no. 12, p. 9, 2013.

Canunal, .. M. *line balancing in the apparel industry using simulation techniques.* izmir turkey. Vol 2,pp 28 -53.

Chandra, P. V. (2013). An Effort To Apply Work And Time Study Techniques.emerald group publishing limited.

Derya Sevim Korkut, N. C. (2009).5S activities and its application at textile industry of turkeyVol 3.

D.Battini et al,2008 "Lean Six Sigma Implementation in Textile Industry," Apr 2017. Australia: School of Engineering Deakin University .

Economic Analysis of Lean Wastes: Case Studies of Textile and Garment Industries in Ethiopia. (2013, Vol. 3, , August).

Ephrem, B. A. (2015). A new perspective to productivity measurement. Total quality management

G. Vijayakumar, Y. R. (2016, April-June). Impacts of lean tools and techniques for improving. University of india.

Groover. (april 2002*). automation production system and computer integrated manufacturing.*

Guillory, A. (2016). Lean Six Sigma applications in textile industry.School of Engineering, University College of Bora° s, Bora° s, Sweden

Habte. (2013). Continuous Improvement in Safety, Quality, and Productivity. Addis ababa university.(2013 ,vol 1)

Jeyaraman, K. (2015, January).A conceptual framework of lean Six Sigma. University of indiavol 2

Khalil A. El-Namrouty, M. S. (2013). Seven wastes elimination targeted by lean manufacturing case.university of india vol 2,pp 23-32.

Králová, M. L. (2010). a simulation Approach To Production Line Bottleneck Analysis Journal of Industrial Engineering, Vol. 12 (4), pp. 292-298.

Mahmood, Kashif . (2015). Productivity Improvement by Implementing Lean. Tallinn University of Technology (Estonia).

Amare Matebu, Daniel Kitaw , 2005 competitiveness of Ethiopian textile and garment industry away forward," "Addis Ababa University, Facility of Technology, Mechanical Engineering Department.

Md. Abdul Moktadir1*, S. A.-T.-Z. (2017). Productivity Improvement by Work Study Technique: A Case on Leather.

Mezgebe, T. T. (August 2013, August 2013). Economic Analysis of Lean Wastes: Case Studies of textile.Addis Ababa

Morse, A. (2014). Morse, A. (2014). EvaluatingThe Impact Of Lean On Employee Ergonomics, Safety, And Job Satisfaction In Manufacturing.

Nunes, I. L. (2007). Merging ergonomic principles into Lean Manufacturing. International Journal of Scientific & Engineering Research

Olena Grinenko, S. K. (2017). global production networks in a global environment.international journal of production Vol 2,

Patel Chintan Kumar. (2013)Set up Reduction techniques. University of india,vol 3,pp103-108.

Pianthong1, N. K. (2007, March – April). The Assembly Line Balancing Problem :" European Journal of Operational Research 149, 417–429.

Prajapati Brijeshkumar, D. D. (2016). A review paper on work study,lean manufacturing and six sigma .university of Delhi

Prathamesh P. Kulkarni1, S. S. (2013). Productivity improvement through lean deployment. .case on garment and textile in Bangladish.

K. Raffia, "textile and garment industry in under developing countries," 2013, Volume: 22, pp: 199-209. Emerald Group Publishing Limited.

Raffia, N. (2000). textile and garment industry in under developing countries.

Rahman, C. M. (2001). Solving Techniques of line balancing problems.vol 2,pp,10 -14.

D. Rajenthirakumar, "Benefits of Implementing Lean Principles to Real Manufacturing," 2015. volume 10,pp; 5 -10. Emerald publishing limited.

Rothenberg, R. D. (2016, 21 August). Lean Six Sigma applications in the textile industry. Vol 3 Hong kong.

Sharon A. Schweikhart, P. a. (2016, May 27,). The Applicability of Lean and Six Sigma Techniques.

Walder, J. K... The integration of lean manufacturing, Six Sigma and sustainability. (2016).

Tan Chan Sin, R. U. (Nov 2014). enginneering mathmatical analysis method for productivity rate August).

Quan and H. Kasami. (2008). value stream mapping in advance lean thinking proven methods to reduce waste and improve quality in health care. Pp.29.

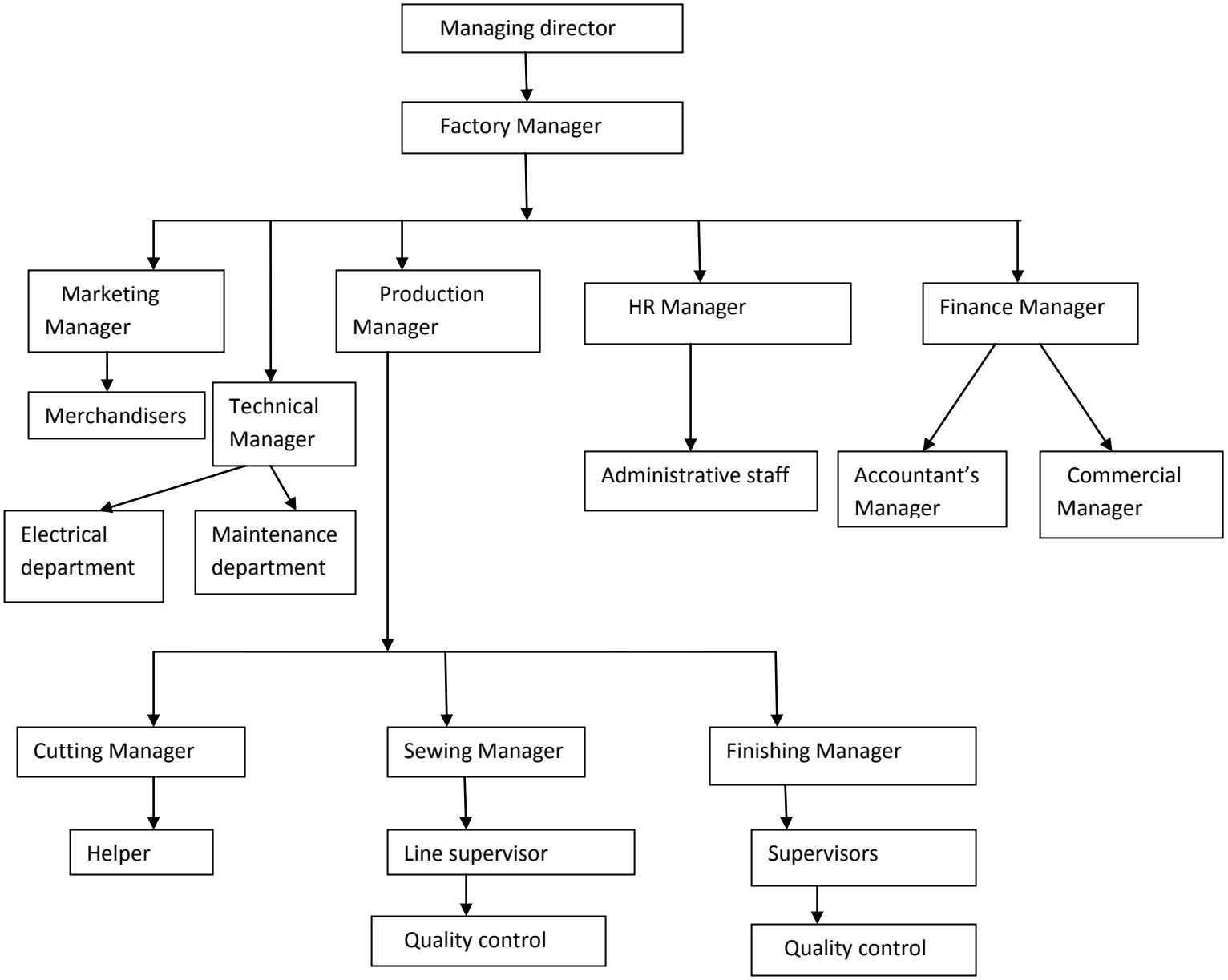
Syum (2010) performance evaluation of selected Ethiopian commercial banks using balanced score card, Mekelle, 2010)

Fiorenzo, F.,Maurizio, G. & Domenico, M., 2007. *Management by Measurement: Designing Key Indicators and Performance Measurement Systems.* Berlin Heidelberg.

Legesse, M.(2016). *Impact of Occupational Safety and Health on Organizational Performance in East Africa Bottling Sh. Co.* Addis Ababa: Addis Ababa University

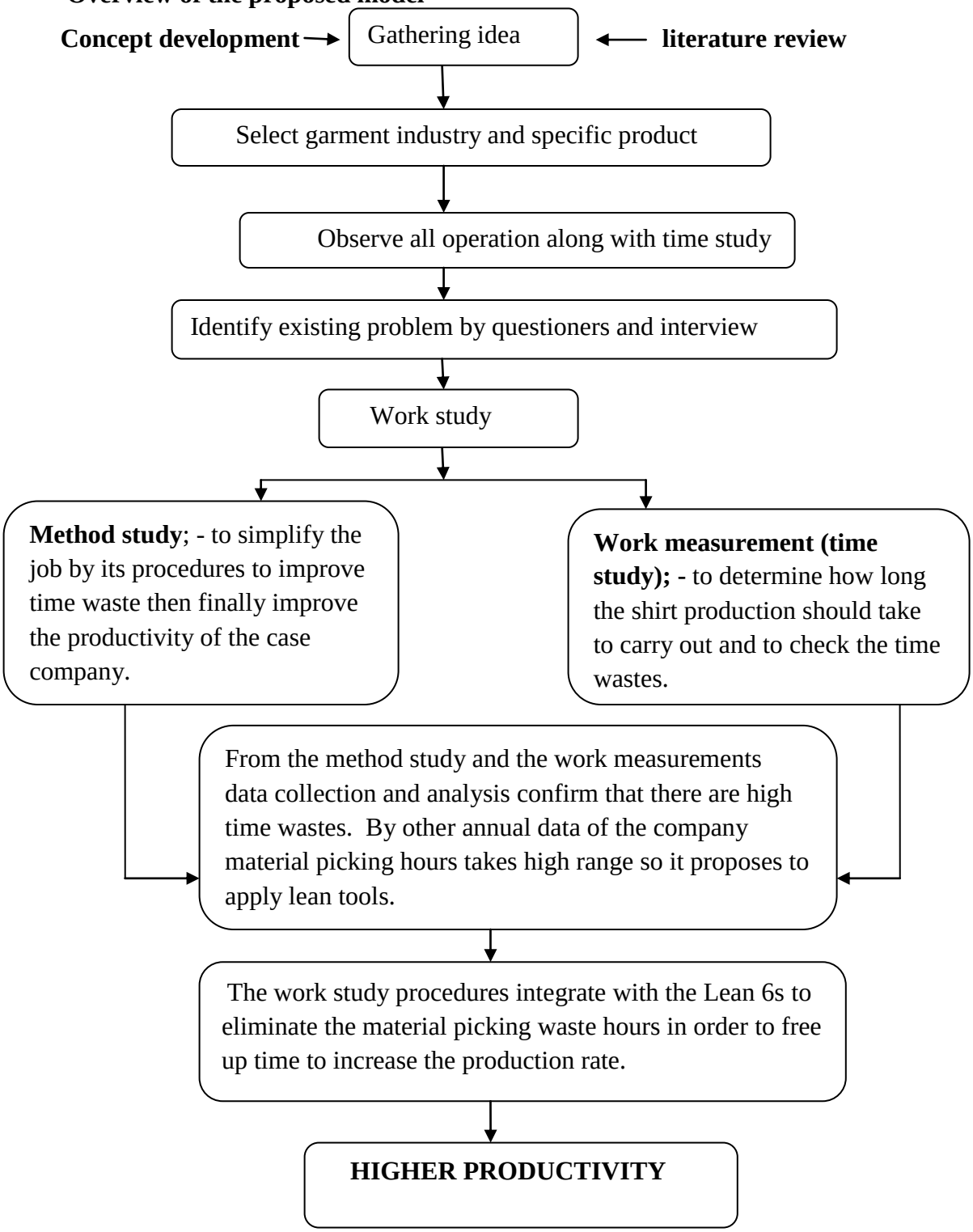
Appendix I

Organizational structure of Addis garment sc.co



Appendix II

Overview of the proposed model



Appendix III

ADDIS ABABA UNIVERSITY

ADDIS ABABA INSTITUTE OF TECHNOLOGY (AAiT)

School Of Mechanical and Industrial Engineering

Graduate Program in Industrial Engineering

Survey Questionnaire on Addis Garment (Augusta) Sc.co

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This questionnaire is prepared to gather data for the purpose of research entitled **"productivity improvement by integrated work study and lean".** The objective of the questionnaire is to improve worker productivity by identifying production problems which have influence on the workers performance. Also to test their understanding about different production wastes those affect both the worker and the process.

I would be very grateful if you could spend a small amount of time to answer the attached questionnaire. All the questions are designed for quick and easy response. If you need further clarification, please contact me on the above address.

Interview Questions for manager

1. How much shirts produce per day?
2. Did the company start export?
3. How much is the standard for operators to produce per shift?
4. How could measure the company productivity?
5. How do identify which part /machine of the manufacturing process/ line limits the output?

6. How much percent did the production fit the standard?

7. How could control the company productivity?

8. How could try to improve the productivity?

9. Did the company give continue training for the workers? Especially on the production section?

10. Is there any over waste in production time, if it is yes what are they and causes of waste?

11. What kind of system the Company use for waste minimization?

12. Did the company use the lean tools for waste minimization?

13. Did the company have experience shearing program with other exporter companies?

Thank you for your cooperation

Appendix IV

Questioner for operators

The purpose of this questioner is to collect data on the factors facing the waste minimization practices Addis PLC. So, you are kindly requested to answer correctly and honestly. These questioner questions are prepared specifically to the employees.

Please rate below questioner to your current organization performance measures and measurement system design, so that ensure the performance measures fulfill the enlisted criteria or not 1=poor 2=fair 3=good 4=very good 5 =excellent and please tick '√' mark in the corresponding cell.

1. General Information;- Indicate your responsibility in your company

Operator ☐ Mechanic ☐ Supervisor ☐ Quality control ☐

other: please specify it----------

ii. Sex male ☐ female ☐

iii. Age

Below 18 ☐ 18-30 ☐ 31-42 ☐ 43-54 ☐ 55 and above ☐

iv. Your educational background

1-8 ☐ 9-10 ☐ 11-12 ☐ TVET ☐ Diploma ☐ BSc ☐

v. Your work experience in this company

Below 1yr ☐ 1-2 yr ☐ 2-5 yr ☐ 5-10 yr ☐ more than 10 years

Waste

s/n	Description of performance in waste controlling	Score				
		1	2	3	4	5
1	transportation					
2	Unnecessary inventory					
3	Unnecessary motion					
4	Inappropriate processing					
5	Over-production					

6	Waiting					
7	Defect					

Customer requirement and market focus

s/n	Description of performance measures	Score				
		1	2	3	4	5
1	On time delivery					
2	Feature					
3	Customer and market focus management.					
4	Aesthetics					
5	Human resource focus.					

Continuous improvement strategies

s/n	Description of performance measures	Score				
		1	2	3	4	5
1	Lean					
2	Kaizen					
3	Training					
4	Work study					

Idle time

s/n	Description of performance measures	Score				
		1	2	3	4	5
1	Machine failure					
2	Material shortage					
3	Power failure					
4	Machine setup					
5	Labor shortage					
6	Material searching					

Thank you for your cooperation, sincerely