PRODUCTIVITY IMPROVEMENT OF CUTTING, SEWING AND FINISHING SECTIONS OF A GARMENT FACTORY THROUGH VALUE STREAM MAPPING – A CASE STUDY

By

Md. Moin Uddin

A project submitted to the Department of Industrial and Production Engineering, Bangladesh University of Engineering and Technology, in partial fulfillment of the requirements for the degree of Master of Engineering in Industrial and Production Engineering.

DEPARTMENT OF INDUSTRIAL & PRODUCTION ENGINEERING
BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY
DHAKA-1000, BANGLADESH

October, 2015

CERTIFICATION OF APPROVAL

The project titled **"PRODUCTIVITY IMPROVEMENT OF CUTTING, SEWING AND FINISHING SECTIONS OF A GARMENT FACTORY THROUGH VALUE STREAM MAPPING – A CASE STUDY"** submitted by Md. Moin Uddin, Roll No. 0411082015P, Session April, 2011 has been accepted as satisfactory in partial fulfillment of the requirements for the degree of **Master of Engineering in Industrial and Production Engineering** on 28 October 2015.

BOARD OF EXAMINERS

Dr. Abdullahil Azeem
Professor,
Department of Industrial and Production Engineering
BUET, Dhaka-1000.

Chairman
(Supervisor)

Dr. M. Ahsan Akhtar Hasin
Professor,
Department of Industrial and Production Engineering
BUET, Dhaka-1000.

Member

Dr. A. K. M. Masud
Professor,
Department of Industrial and Production Engineering
BUET, Dhaka-1000.

Member

CANDIDATE'S DECLARATION

It is hereby declared that this thesis or any part of it has not been submitted elsewhere for the award of any degree or diploma.

Signature of the Candidate

Md. Moin Uddin

ID No: 0411082015P

Date: 28.10.2015

DEDICATION

This project is dedicated to my parents whose tireless encouragement helps me to advance in future.

ACKNOWLEDGEMENT

First, I am very much grateful to the most powerful, the gracious almighty Allah for giving me knowledge, energy and patience for completing the project work successfully.

I would like to express my deepest indebtedness and gratitude to my project supervisor, Dr. Abdullahil Azeem, Professor, Department of Industrial and Production Engineering (IPE), Bangladesh University of Engineering and Technology (BUET), Dhaka, for his continuous guidance, invaluable suggestions, constructive comments and endless encouragement throughout the progress and preparation of this project work.

I am very much thankful to Mr. K. M. Rezaul Hasanat CEO & Chairman, Viyellatex Ltd. for giving me opportunity to implement new methods and ideas in his factory. I also express my gratitude to Mr. Parvez Saiful Islam (COO), Mr. Javed Iqbal (DGM), Mr. Abdur Razzak (Head of production), Mr. Robiul Islam (Head of Eco-Couture), Mr. Abul Kalam Azad, Mr. Nazmul Alam and workers and staffs of viyellatex Ltd. Gazipur, for their cordial support and cooperation by providing me the respective information, valuable time and great support during the assessment and implementation phase while I was working there as Head of IE and Lean, and also for my project work. I am also thankful to my colleagues Mr. Mahabub Alam, Executive (Lean), and my team who has given their support and cooperation all time.

In addition, thanks are due to those who helped me directly and indirectly during the different stages of the project work.

Finally, I would like to convey my sincere gratitude to my parents whose continuous inspiration, sacrifice and support encouraged me to complete the project successfully.

ABSTRACT

On time delivery with quality and quantity is important for any manufacturing industry. At present, lead time is decreasing day by day and customer requirements also continuously changing. To fulfill customer demand whole production system should be more capable and efficient. For this reason productivity is important for manufacturing industries. Productivity can be defined as a ratio between output and input.

Manufacturing industries are always having lots of production processes for desired products. Out of these processes some are not essential and do not add any value to the product. Most of time, management is not quite aware of the non-value-adding processes. If we observe a garments production line we will see that there were lots of In-process inventories and waiting time between almost every sequential operation. No strict and precise work distribution was followed by many workers. Material's used to travel large distance from input receiving to needle check and cartooning. Many of these movements and handlings are totally unnecessary. Sometimes reworks are increasing the total completion time. As a result, the productivity was hampered. So, a smooth, streamlined and continuous flow is really necessary to avoid all such unexpected occurrence.

The objective of value stream mapping is to identify value-added activities and non-value-added activities. Value stream maps should reflect what actually happens rather than what is supposed to happen so that opportunities for improvement can be identified. Value Stream Mapping is often used in process cycle-time improvement projects since it demonstrates exactly how a process operates with detailed timing of step-by-step activities. It is also used for process analysis and improvement by identifying and eliminating time spent on non-value-added activities.

The present study focuses on improving the overall productivity of cutting, sewing and finishing sections through value stream mapping (VSM). Different techniques like process integration, job sharing, multitasking etc. will be implemented to improve the current state situation. Three different product lines (Jacket, Polo shirt, and tee shirt) will be considered to implement this study, and the productivity as well as line efficiency will be compared before and after implementing the technique.

TABLE OF CONTENTS

CHAPTER 6: FUTURE STATE MAPPING AND IMPLEMENTATION

CHAPTER 7: DATA ANALYSIS AND RESULTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER ONE

INTRODUCTION

1.1 Introduction

Industrialization is the key to the economical development of the country. The Ready Made Garments (RMG) industry is the major export – base (75%) for Bangladesh and it has major impact on country's economy, as well as on society, because of large number of worker involvement. To meet the ever increasing demand of the mass population and the international demand of the textile products, the emerging and important sector of national economy, the RMG sector has the great chance and opportunity to improve the productivity. Because of being technologically labor dependent it has a large number of worker involvement and most of them are female worker so it helps in socio – economical development of the poor fraction of population of the country. So the females are playing an important role in the largest foreign exchange earning sector of our country and they are becoming conscious about women rights by their economic independency. The garments industries in Bangladesh do have the organizational structure but do not have the proper job description of the employees so the problem arises from the mid-level management. Description of rules and responsibilities along with power and authority is essential for smooth production running of any organization. In today's competitive world the manufacturers needs to be conscious about time, cost, quality and delivery. To be the champion in business these four components should be given most priority along with good management skill and innovative technological aspects of modern development. The present situation of the RMG sector is not in a satisfying one and in the last year there was a massive worker agitation because of salary structure, working environment, compliance issues and other human rights. The local garment manufacturers are facing fierce competition in Quota and GSP free market as per WTO agreement and they are well behind from the competing countries like India, Sri Lanka, China, Indonesia and Vietnam etc. In order to face the challenges Bangladeshi manufacturers have to apply new methods, tools and techniques in different area of production and operation management and in other business areas.

After the World War II Japanese manufacturers, particularly in the automotive industry, were faced with the dilemma of shortages of material, financial and human resources. Eiji Toyoda and Taiichi Ohno at the Toyota Motor Company in Japan pioneered the concept of the Toyota Production System (TPS), or what is known today as "Lean Manufacturing". Lean manufacturing is a new term defined by Womack and Jones that helps the manufacturer to produce quality product with less material, greater efficiency, shorter lead time, and in timely manner. Lean has many tools for better manufacturability and it needs proper guideline, management involvement, appropriate knowledge and overall factory transformation to the system.

Productivity can be defined as a ratio between output and input. Productivity improvement is a critical success factor and the foundation of profitability [1]. Productivity measurement is a long-term measurement. Any changes in dynamic potential show a growth or reduction of figures over a long period [2].

The thesis addresses the application of lean manufacturing concepts to the mass production sector (RMG) with a focus on the value chain of garment industry including cutting, sewing, finishing. The objective of the study is to investigate the present status of the industry, scope of improvement and the benefit gain by the implementation of new tools of lean manufacturing.

1.2 Rationale of the study

The challenges faced by local apparel manufactures can be addressed by the systematic analysis of the manufacturing system and link their problem with the lean tools and techniques to create value for customers.

The application of lean manufacturing in a business or manufacturing environment, describes a philosophy that incorporates a collection of tools and techniques into the business processes to optimize time, human resources, assets, and productivity, while improving the quality level of products and services to their customers. If the application of lean manufacturing produces positive impact on productivity, quality and lead time it may have snow ball effects on the whole apparel sector of the country.

1.3 Background of the project

The application of lean manufacturing concept in RMG sector is totally new in Bangladesh. So there is a great necessity to study the scope of implementation and the areas of improvement and the step by step methodology to do it in a positive and learned thinking. The productivity, efficiency and effectiveness are increasingly becoming the burning issue in today's economy. To survive in the hard contest economy the industry should develop itself with systematic identification and elimination of waste, productivity improvement, cost reduction, employee benefit incentives and social welfare activities. Now a days the buyers are searching market for lower price and they are getting new exporter on their hand with their requirement. So the profit margin is narrowing and the competition is expanding as a result the production process and new technology is the only way to cope up the crisis. The project work tries to find out the common phenomenon to implement lean tools and the barriers to overcome.

1.4 Problem statement

The ever increasing demand from buyer's side to reduce cost, improve quality and shorter period of lead time as well as smaller quantity orders as well as increasing of labor cost has forced the local apparel manufactures to search for improving labor productivity, quality and reducing lead time to stay competitive in the business and thrive. In this scenario, application of tools and techniques of Lean manufacturing and industrial engineering could benefit the local apparel manufactures tremendously.

1.5 Objective of the study

The specific objectives of this project work are:

1. To identify different types of waste in cutting, sewing and finishing sections
2. To improve productivity of assembly lines by implementing different process improvement techniques using existing resources

The possible outcome of the proposed work is to develop an improved production line model that can enhance the overall productivity of the system.

1.6 Methodology

The methodology of the study will be as follows:

1. Collecting information from the cutting, sewing and finishing departments
2. Developing a current state map using the collected information
3. Analyzing the current state map to identify the potential areas for improvement
4. Define value adding & non value adding task
5. Make a summary sheet percentage of value adding & non value task
6. Reduce non value added task by process improvement
7. Designing a future state map by eliminating wastes reduce lead time also
8. Analyzing improvement compared to present state

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

Lean manufacturing is a set of tools and methodologies that aims for the continuous elimination of all waste in the production process i.e. a system for improving productivity & product quality. Laconically more value with less work.
Lean manufacturing is a manufacturing philosophy that shortens the time between the customer order and the product build or shipment by eliminating sources of waste. Another way of looking at lean is that it aims to achieve the same output with less input- less time, less space, less human effort, less machinery, less material, less costs. Today's manufacturers must be innovative while focusing on waste reduction, improved lead-time, maximized flexibility, and upgraded quality. Lean manufacturing concepts are proven strategies to help manufacturers obtain these attributes.

2.2 Historical Background

The industrial revolution has begun 1860. After 1885 the Henry Ford model of assembly line production caused a manufacturing transformation from individual craft production to mass production. Ford was able to transform iron ore into an automobile in just 33 hours.

Sakichi Toyoda learned carpentry from his father in and eventually applied that skill to designing and building wooden spinning machines. In 1894 he began to make manual looms that were cheaper but worked better than existing looms. Sakichi Toyoda establishes Toyota Spinning & Weaving Co., Ltd, in 1918 later referred to as Japan’s King of Inventors.

By 1925, and even though GM’s cost always remained higher than Ford’s, Sloan’s strategy was working. He commented: “Ford’s precious volume, upon which all depended, began slipping.” Ford responded by cutting prices to the bone, to no avail: the fact was that even at this price, the Model T no longer provided an attractive value proposition to the customer, and by 1928 was driven from the market.

Ford made history of the horse and buggy, so too did GM's Alfred P. Sloan make history of the Model T. Ford made Model T-Car which was mass produced and was cheap. *Customer could get any color of model T as long as it was black*. Sloan repositioned the car companies to create a five-model product range from Chevrolet to Cadillac. The challenge in manufacturing during the 1930s shifted to product variety. As Sakichi found that his mother, grandmother & their friends had to so hard spinning & weaving. In 1926, He started Toyoda Automatic Loom Works with the help of steam engine.

His mistake-proof loom (when thread breaks, the m/c stopped) became Toyoda's most popular model, and in 1929 he sent his son, Kiichiro, to England to negotiate the sale of the patent rights to Platt Brothers, the premier maker of spinning and weaving equipment. His son negotiated a price of $500,000 and in 1930 he used that capital to start building the Toyota Motor Corporation. In 1933 Automobile Department is created within Toyoda Automatic Loom Works. Sakichi Toyoda was undoubtedly aware that the world was changing and power looms would become yesterday's technology while automobiles were tomorrow's technology. But more than this, he had put his mark on the industrial world through loom making and wanted his son to have his opportunity to contribute to the world. He explained to Kiichiro: "Everyone should tackle some great project at least once in their life. I devoted most of my life to inventing new kinds of looms. Now it is your turn. You should make an effort to complete something that will benefit society."

Kiichiro's father sent him to the prestigious Tokyo Imperial University to study mechanical engineering; he focused on engine technology. Despite his formal engineering education, he followed in his father's footsteps of learning by doing. In 1935 First Model A1 passenger car prototype is completed through trial & error. (Over four five years in rural village, industrious almost illiterate pheasant, automotive factory develop, after few years first car rolled out) Kichiro built Toyota Automotive Company on his father's philosophy and management approach, but added his own innovations. For example, while Sakichi Toyoda was the father of what would become the jidoka pillar of the Toyota Production System, Just-In-Time was Kiichiro Toyoda's contribution. His ideas were influenced by a study trip to Ford's plants in Michigan to see the automobile industry as well as seeing the U.S. supermarket system of replacing products on the shelves just in time as customers purchased them. In 1937 Toyoda Automatic Loom founded as Toyota Motor Co., Ltd. As the 1950s began, demand for specialized products started to take hold. Not only were products more specialized, but they also had limited life cycles. Batch manufacturing methods had arrived! What is the optimum amount? How much is too much? In the 1950s, American style supermarket appeared in Japan in Japan, initiated new thinking & limited application. In 1956, Ohno visited America to learn first-hand (genchi genbutsu) how supermarket operated. Around the early 1960s**,** as computing power began to be more cost effective, early pioneers began the development and installation of the early computer-based MRP systems. While an MRP system is a valuable weapon in the manufacturing arsenal, practitioners continue to grapple with the still conflicting objectives of batch manufacturing and optimizing inventories. During the 1950s and 1960s Toyota contended that the standard thinking of Cost plus Profit equals Sales Price was incorrect. It believed that Profit equals Sales Price minus Costs. From this premise, Toyota concentrated on the management of costs means wastes and wastes of all varieties were targeted for elimination.

Key areas targeted were work-in-process inventory and safety stock. While many companies in the United States and Europe were attempting to calculate the optimum batch sizes for production, Toyota worked toward the goal of being able to build a mix of products in a one-piece flow. Having the capability to build a mix of products in a one-piece flow (mixed-product Lean line) satisfied many key objectives for Toyota, raising productivity and reducing costs and inventory while simultaneously creating rapid customer response.

Through the 1960s and into the 1970s, these two models of manufacturing developed down separate paths. One sought better ways to manage batch production by making ongoing improvements to the MRP planning model, while the other concentrated on finding and fine-tuning ways to allow a one-piece flow of a mix of products

By the 1980's Toyota had increasingly become known for the effectiveness with which it had implemented Just-In-Time (JIT) manufacturing systems. Many product markets in the United States and Europe started to come under pressure from Japanese manufacturers. Western manufacturers began to lose market share. Some manufacturers faded away while others began to look diligently for better ways to compete. Many abandoned the old batch manufacturing models in favor of the more responsive method of Toyota and 1990 the term "Lean Manufacturing" or "Lean Production" first appeared in the book "*The Machine that Changed the World*" by James P Womack, Daniel T Jones, Daniel Roos.

2.2.1 The Ford System

Starting about 1910, Ford and Charles E. Sorensen [3], fashioned the first comprehensive Manufacturing Strategy. They took all the elements of a manufacturing system-- people, machines, tooling, and products-- and arranged them in a continuous system for manufacturing the Model T automobile. Ford is considered by many to be the first practitioner of Just in Time and Lean Manufacturing.

Ford's success inspired many others to copy his methods. But most of those who copied did not understand the fundamentals.

For example, Ford production [4] depended on a labor force that was so desperate for money and jobs that workers would sacrifice their dignity and self-esteem. The prosperity of the 1920's and the advent of labor unions produced conflict with the Ford system. Product proliferation also put strains on the Ford system.

At General Motors, Alfred P. Sloan took a more pragmatic approach to production and developed business strategies for managing very large enterprises and dealing with variety. By the mid 1930's General Motors had passed Ford in domination of the automotive market.

2.2.2 Just in Time and Toyota Production System

The Allied victory and the massive quantities of material behind it caught the attention of Japanese industrialists. They studied American production methods with particular attention to Ford practices and the Statistical Quality Control practices of Ishikawa, Edwards Deming, and Joseph Juran. At Toyota Motor Company, Taichii Ohno and Shigeo Shingo, began to incorporate Ford production, Statistical Process Control and other techniques into an approach called Toyota Production System or Just in Time [5]. They recognized the central role of inventory.

The Toyota people also recognized that the Ford system had contradictions and shortcomings, particularly with respect to employees. With General Douglas MacAurthur [6] actively promoting labor unions in the occupation years, Ford's harsh attitudes and demeaning job structures were unworkable in post-war Japan. Toyota soon discovered that factory workers had far more to contribute than just muscle power. This discovery probably originated in the Quality Circle movement. Ishikawa, Deming, and Juran all made major contributions to the quality movement. It culminated in team development and cellular manufacturing.

Another key discovery involved product variety. Shingo, at Ohno's suggestion, went to work on the setup and changeover problem. Reducing setups to minutes and seconds allowed small batches and an almost continuous flow like the original Ford concept.

All of this took place between about 1949 and 1975. To some extent it spread to other Japanese companies. When the productivity and quality gains became evident to the outside world, American executives traveled to Japan to study it. They brought back, mostly, the superficial aspects like kanban cards and quality circles. Most early attempts to emulate Toyota failed because they were not integrated into a complete system and because few understood the underlying principles [7].

2.2.3 Lean Manufacturing

Liker and Wu [8] define “lean” as “a philosophy of manufacturing that focuses on delivering the highest-quality product at the lowest cost and on time. It is a system of production that also takes a value stream focus. The ‘value stream’ consists of all the steps in the process needed to convert raw material into the product the customer desires.”

Although lean manufacturing has its origins in the automobile manufacturing sector, other industries have adopted the practices to improve their own operations. Womack and Jones [9] offer several case studies of firms making radically different products, including stretch-wrapping machines, wire management systems and power protection devices, and aircraft engines, among others. Liker [10] reports improvements for a tannery, a maker of sealing components, a scientific products company, a maker of outdoor cedar products (including birdhouses), a manufacturer of seismic exploration equipment, and companies in the automobile supply chain.

In the late 1980s, the International Motor Vehicle Program (IMVP) at the Massachusetts Institute of Technology (MIT) studied automobile manufacturers and compared the United States, Europe, and Japan, to learn the source of the Japanese advantage. The book that was published from this project, The Machine that Changed the World, [11] introduced the term “lean manufacturing” to the United States. The authors argued that rather than one or another particular cultural factor, process improvement, or organizational technique being responsible for Japan’s success, it was the manufacturing system as a whole. They found that a comprehensive system based on, among other things, maintaining minimal inventories and very high quality, was the basis for the success of the Japanese manufacturers, particularly Toyota. There are many overlaps with the total quality management (TQM) system, although the authors never mention this (Babson, 1995).

Indeed, a number of books written prior to the work of Womack and his associates addressed many of the same concepts. Ohno wrote Toyota Production System: Beyond Large-Scale Production in 1978 [12], Shingo’s A Study of the Toyota Production System from an Industrial Engineering Viewpoint was first translated into English in 1981, Monden wrote Toyota Production System in 1983, Goldratt and Cox published the first edition of The Goal in 1984, Schonberger penned World Class Manufacturing in 1986, and Suzaki wrote The New Manufacturing Challenge in 1987 [13].

However, The Machine that Changed the World [11] was an enormously popular book with managers and was a tremendous sales document for the lean manufacturing system. A second book by two of the same authors, Womack and Jones, Lean.

Lean Thinking [9], has offered another take on lean manufacturing, and provides examples of companies outside the automobile sector that had successfully adopted the system.

More recently, two books – Running Today’s Factory (1999) by Charles Standard and Dale Davis and The Toyota Way [10], by Jeffery Liker – have provided a more clear description of Lean Manufacturing Principles and how to apply them.

A research work carried out on “Analysis of Apparel Production Systems to Support Quick Response Replenishment” by Russel E. King (Team Leader), Thom J. Hodgson (NCSU Engineering); Trevor Little, Carol Carrere (NCSU Textiles); Michelle Benjamin, Tim Currin (Textile Clothing Technology Corporation). The goal of this project was to determine the structure and operational policies of apparel supply systems to best support rapid replenishment to retail in order to maximize performance and productivity.

A paper named “An Integrated Methodology for More Effective Setup Reduction” was presented at the IIE Solutions 2001 conference organized by the Institute of Industrial Engineers, in Dallas, TX (21-23 May 2001). This paper describes how setup time is being reduced when different types of IE Techniques and SMED are combined together.

CHAPTER THREE

LEAN MANUFACTURING

3.1 Introduction

Lean thinking focuses on value- added flow and the efficiency of the overall system. A part sitting in a pile of inventory is waste and the goal is to keep product flowing and add value as much as possible. The focus is on the overall system and synchronizing operations so that they be aligned and produced products at a steady pace.

3.2 Principle of Lean Manufacturing

Key principles behind Lean Manufacturing can be summarized as follows:

1. *Recognition of waste* – The first step is to recognize what does and does not create value from the customer's perspective. Any material, process or feature which is not required for creating value from the customer's perspective is waste and should be eliminated.

2. *Standard processes*- Lean requires an the implementation of very detailed production guidelines, called Standard Work, which clearly state the content, sequence, timing and outcome of all actions by workers. This eliminates variation in the way that workers perform their tasks.

3. *Continuous flow*- Lean usually aims for the implementation of a continuous production flow free of bottlenecks, interruption, detours, back flows waiting. When this is successfully implemented. The production cycle time can be reduced by as much as 90%.

4. *Pull-production*- Also called Just-in- Time (JIT), Pull- production aims to produce only what is needed, when it is needed. Production is pulled by the downstream workstation so that each workstation should only produce what is requested by the next workstation.

5. *Quality at the Source*- Lean aims for defects to be eliminated at the source and for quality inspection to be done by the workers as part of the in-line production process.

6. *Continuous improvement* – A continuous improvement mentality is necessary to reach the company's goals. The term "Continuous improvement" means incremental improvement of products, processes, or services over time, with the goal of reducing waste to improve workplace functionality, customer service, or product performance.

Lean requires striving for perfection by continually removing layers of waste as they are uncovered. This in turn requires a high level of worker involvement in the continuous improvement process.

7. *Customer focus* – A lean manufacturing enterprise thinks more about its customers than it does about running machines fast to absorb labor and overhead. Ensuring customer input and feedback assures quality and customer satisfaction, all of which support sales.

8. *Value* –In lean production, the value of a product is defined slowly by the customer. The product must meet the customer's needs at both a specific time and price. Identifying the value in lean production means to understand all the activities required to produce a specific product, and then to optimize the whole process from the view of the customer.

9. *Perfection* - The concept of perfection in lean production means that there are endless opportunities for improving the utilization of all types of assets. The systematic elimination of waste will reduce the costs of operating the extended enterprise and fulfils customer's desire for maximum value at the lowest price [14]

3.3 Value & Waste

Waste is anything that does not contribute to transforming a part to the customer's needs. The aim of Lean Manufacturing is the elimination of waste in every area of production including customer relations, product design, supplier networks, and factory management. Its goal is to incorporate less human effort, less inventory, less time to develop products and less space to become highly responsive to customer demand while producing top quality products in the most efficient and economical manner possible. Essentially, a "waste" is anything that the customer is not willing to pay for [15].

3.3.1 Types of waste

There are seven types of waste which are following-

3.3.2 Overproduction

Producing more material than the customer demand or produce it before it is need is termed as overproduction. Overproduction means making more than is required by the next process, making earlier than is required by the next process, or making faster than is required by the next process. The corresponding Lean principle is to manufacture based upon a pull system, or producing products just as customers order them. It is visible as storage of material. It is the result of producing to speculative demand. Causes of overproduction time include:

- Just in case logic
- Lack of feedback from downstream process
- Lack of balance between
- Misuse of automation.

3.3.3 Waiting

Material waiting is not material flowing through value-added operations. This includes waiting for material, information, equipment, tools, etc. Lean demands that all resources are provided on a just-in-time (JIT) basis- not too soon, not too late [16].

Waiting for a machine to process should be eliminated. The principle is to maximize the utilization or efficiency of the worker instead of maximizing the utilization of the machines. Causes of waiting time include:

- Long set up times
- Lack of balance between processes namely engineering, workload, automation, scheduling etc.
- Unplanned maintenance
- Lack of redundancy wherever possible
- Quality problems in upstream process.

3.3.4 Inventory or work in process (WIP)

Work in Process (WIP) Inventory is material between operations due to large lot production or processes with long cycle times. Material sits taking up space, costing money, and potentially being damaged. Related to Overproduction, inventory beyond that needed to meet customer demands negatively impacts cash flow and uses valuable floor space. Causes of work in process time include:

- Poor communication
- Inadequate market research
- Just in case logic
- Fluctuations in materials procurement
- Poor scheduling.

- Protecting the company from inefficiencies and unexpected problems
- Product complexity
- Unbalanced workload
- Unreliable shipments by suppliers
- Misunderstood communications
- Reward systems.

3.3.5 Over processing

Correction, or reprocessing, is when something has to be re-done because it wasn't done correctly the first time. Taking unneeded steps to process the parts, inefficiently processing due to poor tool and product design, causing unnecessary motion and producing defects. Waste is generated when providing higher-quality products than is necessary.

This not only results in inefficient use of labor and equipment but the act of re-processing often causes disruptions to the smooth flow of production and therefore generates bottlenecks and stoppages. Also, issues associated with reworking typically consume a significant amount of management time and therefore add to factory overhead costs. Causes for over processing waste include:

- Product changes without process changes
- Just-in-case logic
- True customer requirements undefined
- Over processing to accommodate downtime
- Lack of communication
- Redundant approvals

3.3.6 Transportation

Transportation includes any movement of materials that does not add any value to the product, such as carrying work in process (WIP) long distances, creating inefficient transport, or moving materials, parts, or finished goods into or out of storage or between processes.

The idea is that transportation of materials between productions stages should aim for the ideal that the output of one process is immediately used as the input for the next process. Transportation between processing stages results in prolonging production cycle times, the inefficient use of labor and space and can also be a source of minor production stoppages. Causes of transportation time include:

- Poor plant layout
- Poor understanding of the process flow for production
- Large batch sizes, long lead times and large storage areas.

3.3.7 Unnecessary Motion

Motion includes any unnecessary physical motions or walking by workers which diverts them from actual processing work. For example, any wasted motion employees have to perform during the course of their work, such as looking for, reaching for, or stacking parts, tools, difficult physical movements due to poorly designed ergonomics, which slow down the workers. Also, walking is waste. Causes of motion waste include:

- Unskilled people and machine ineffectiveness
- Inconsistent work methods
- Unfavorable facility or cell layout
- Poor workplace organization and housekeeping
- Extra “busy” movements while waiting.

3.3.8 Defects

Production of defective parts or correction, repair or rework, scrap, replacement production, errors in paperwork, provision of incorrect information about the product, late delivery, and inspection mean wasteful handling, time, and effort. Defects emerge from one or more of these items:

- Poor product design
- Misunderstanding of customer needs
- Lack of skills and work instructions
- Unsatisfactory planned maintenance
- Low quality
- Storages of process control.

3.4 Push System

In a push system, the demand (often forecast because the lead times are so long) is converted to a schedule for each operation. The material is released to the first operation, as dictated by the schedule, and it is progressed ("pushed") through the subsequent operations.

3.5 Pull System

In a pull system, the demand (often customer demand as lead times are usually short) is the production schedule of the last operation. This operation asks the previous operation for work only when it needs it to fulfill the customer demand. The previous operation then asks the one before it and so on. The fundamental rule is that material is only worked on if the customer demands it. In this way material is "pulled" through the previous operations [17].

3.6 Workplace Organization-5S

The Five S's are some rules for workplace organization which aim to organize each worker's work area for maximum efficiency [18].

3.6.1 First pillar: Sort (Seiri)

Sort what is needed and what is not needed so that the things that are frequently needed are available nearby and as easy to find as possible. Things which are less often used or not needed should be relocated or discarded.

An effective visual method to identify these unneeded items is called "red tagging", which involves evaluating the necessity of each item in a work area & dealing with it appropriately. A red tag is placed on all items that are not important for operations or that is not in the proper location or quantity.

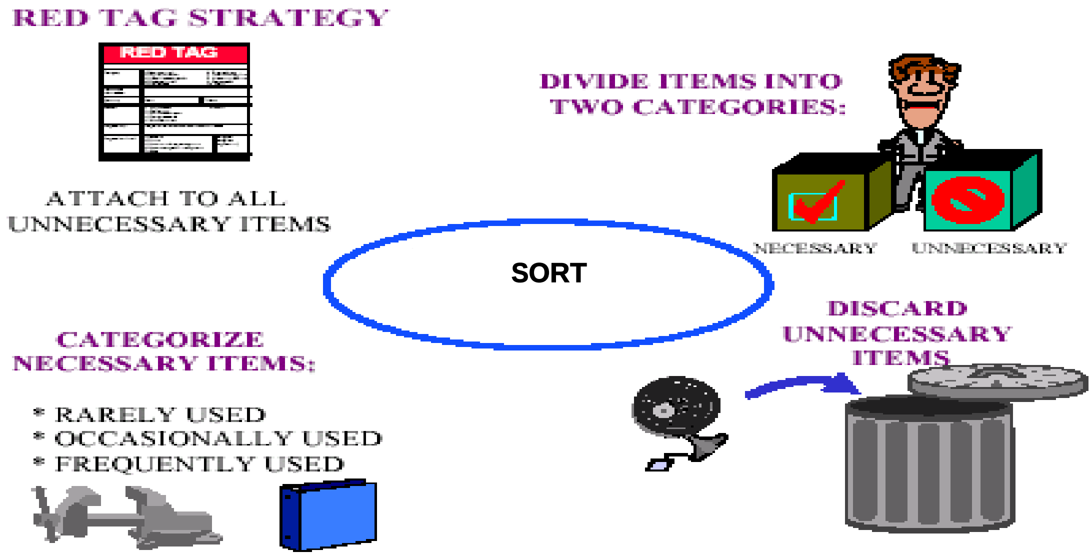


Figure 3.1: Sort of 5S

3.6.2 Second pillar: Set in Order (Seiton)

Set in order – Arrange essential things in order for easy access. The objective is to minimize the amount of motion required in order for workers to do their jobs. For example, a tool box can be used by an operator or a maintenance staff who must use various tools. In the tool box, every tool is placed at a fixed spot that the user can quickly pick it up without spending time looking for it. This way of arrangement can also help the user be immediately aware of any missing tools.

3.6.3 Third pillar: Shine (Seiso)

Shine means keep machines and work areas clean so as to eliminate problems associated with un-cleanliness. In some industries, airborne dust is among the causes of poor product surface or color contamination. To be more aware of dust, some companies paint their working places in light colors and use a high level of lighting.

3.6.4 Fourth pillar: Standardize (Seiketsu)

Standardize is make the first 3S's a routine practice by implementing clear procedures for sorting, straightening and scrubbing.

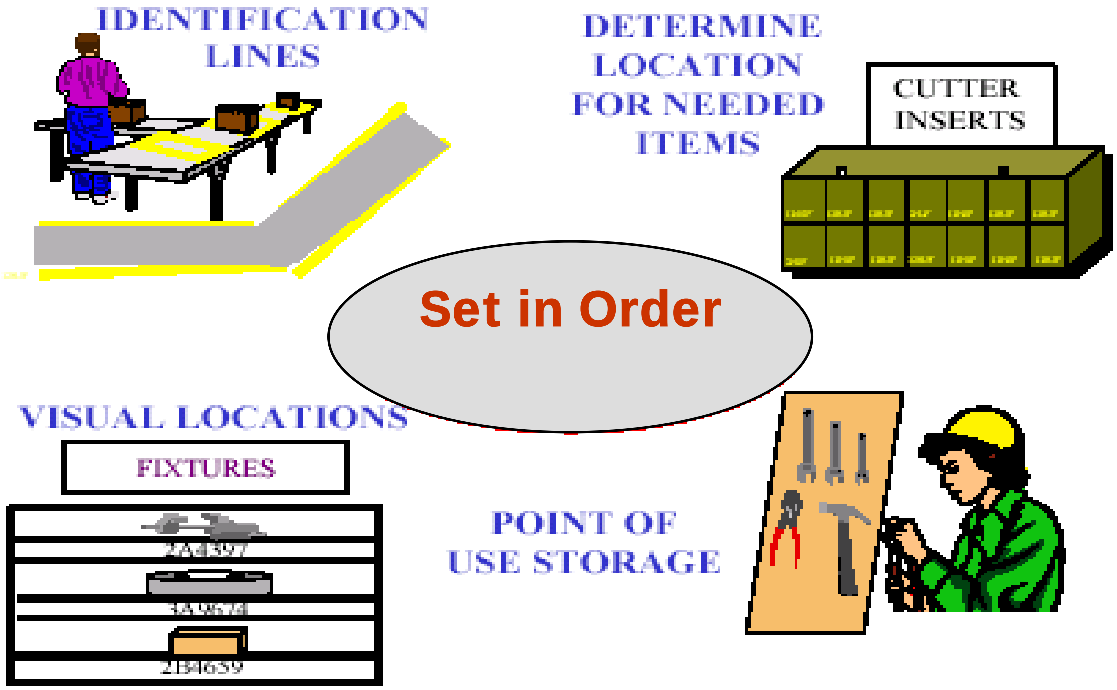


Figure 3.2: Set in Order of 5S

3.6.5 Fifth pillar: Sustain (shitsuke)

Sustain – Promote, communicate and train in the 5 S's to ensure that it is part of the company's corporate culture. This might include assigning a team to be responsible for supervising compliance with the 5 S's.

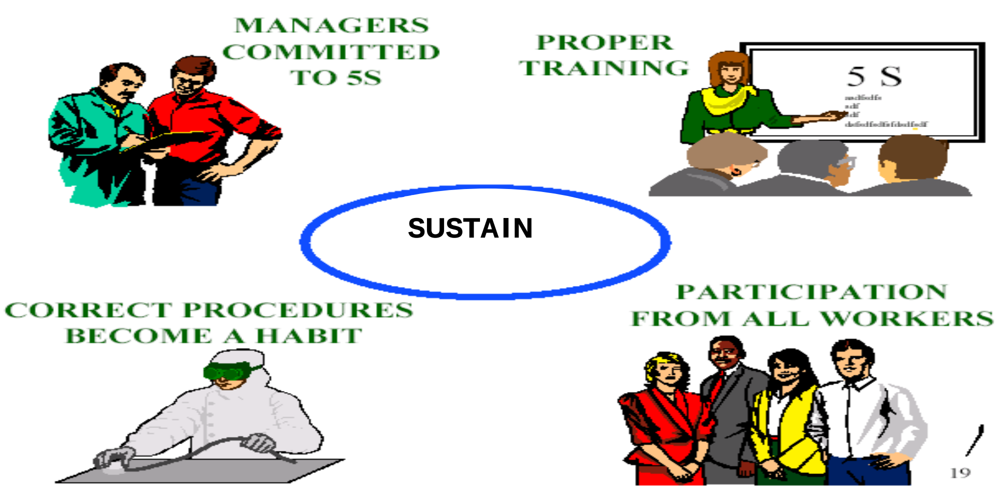


Figure 3.3: Sustain of 5S

3.6.6 The benefits of 5S

- Improves safety
- Better working environment
- 5S can significantly improve space utilization space
- Easy retrieval of material, information, tools etc.
- Reduce quality problems
- Lower costs
- Increased customer satisfaction and
- Discipline in workplace etc.

3.7 Visual Management

Visual Management systems enable factory workers or anyone interested to be well informed about production procedures, status and other important information for them to do their jobs as effectively as possible. Large visual displays are generally much more effective means of communication to workers on the factory floor than written reports and guidelines and therefore should be used as much as possible. When it comes to improving compliance with a process, visual presentation helps the team better understand a complicated process including the correct sequence of events, the correct way to perform each action, internal and external relationships between actions, and other factors which may help them to improve. These visual tools may include the following:

a. **Visual Displays -** Charts, metrics, procedures and process documentation which are reference information for production workers. For example, trend chart of yield performance, % variation of defect rate, month-to-date shipping volume status, etc.

b. **Visual Controls** – Indicators intended to control or signal actions to group members. This may include production status information, quality tracking information, etc. For example, color-coded panel for temperature or speed setting control limits that help an operator quickly identify process is out of the control range. Kanban cards are another example of visual controls. Lines on the floor to delineate storage areas, walkways, work areas etc. Lights to indicate production status.

c. **Visual process indicators** – These communicate the correct production processes or flow of materials. For example, this would include the use of painted floor areas for non-defective stock and scrap or indicators for the correct flow of materials on the factory floor. Visual Workplace Supports the “Eight Zeros**”**

i. Zero waste

ii. Zero defects

iii. Zero downtime

iv. Zero customer complains

v. Zero injuries

vi. Zero delays

vii. Zero loss

viii. Zero changeovers

3.8 Kanban

Kanban is the Japanese word for card or signal. In terms of card, a kanban is used to make issues like inventory status, parts location and production status more visible. In terms of signal, a kanban authorizes the previous stage of production to make more parts.

A kanban uses a designated workspace between operations to balance supply with demand. It means a visible record. Kanban triggers mechanism to make or move material. The result is that kanbans create a simple to operate, visible control system that offers the opportunity to delegate routine material control transactions to the shop floor. It is simple and inexpensive. It sets priority, limits inventory, and exposes problems.

3.9 Quick Changeover

Elapsed time between the last good piece from previous product, and the first good piece from next product at the right speed.

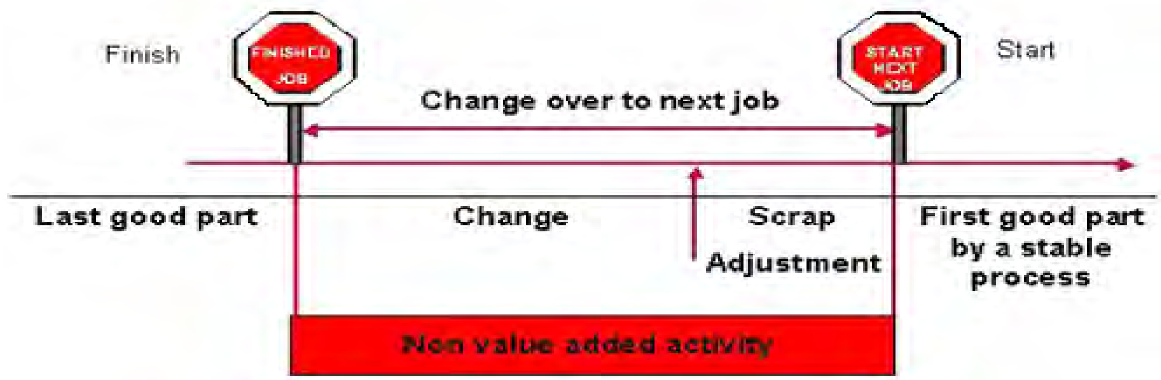


Figure 3.4: Quick Change Over

Lean Manufacturing aims to reduce unnecessary downtime due to machine setup or product changeovers since machine downtime is a significant source of unnecessary waste. This requires a culture of continuous improvement in which the company is continuously trying to find ways to reduce changeover and setup times. Often quicker changeover times can be achieved to some degree by having very standardized (and well-documented) configuration settings for the production of particular products so that there is no uncertainty about how to reconfigure the equipment during a changeover. Companies with a wide range of product mix, color and specifications often underestimate the conversion cost every time the production process is halted to replace molds, clean leftover materials with a different color or specification, adjust machine settings, etc.

Other ways to minimize the changeover/setup time include changing the physical layout of a process, having all materials and tools needed available, and using dual/spare storage bin to eliminate cleaning downtime.

3.10 Kaizen

It is a Japanese term for “continuous improvement”, with an emphasis on small incremental improvements. A main theme of Kaizen is to create a culture of continuous improvement, largely by assigning responsibility to workers, and encouraging them, to identify opportunities for improvement.

A company can never be perfectly efficient. Lean Manufacturing requires a commitment to continuous improvement, and preferably a systematic process for ensuring continuous improvement, whereby the company constantly searches for non value-added activities and ways to eliminate those. The focus of continuous improvement should be on identifying the root causes of non-value-added activities and eliminating those by improving the production process.

Two main opportunities for improvement are:

1. The elimination of Muda (waste) from processes
2. The correction of any issues/problems within processes in addition to Muda

The relevance of Muda is that it both directly causes problems and also hides or disguises other issues or problems that are occurring within a process. It is therefore the most important element to eliminate from a process. In manufacturing companies, Kaizen consists of eliminating waste in machinery, workers and production methods. (Graphic Products, Inc. 2000)

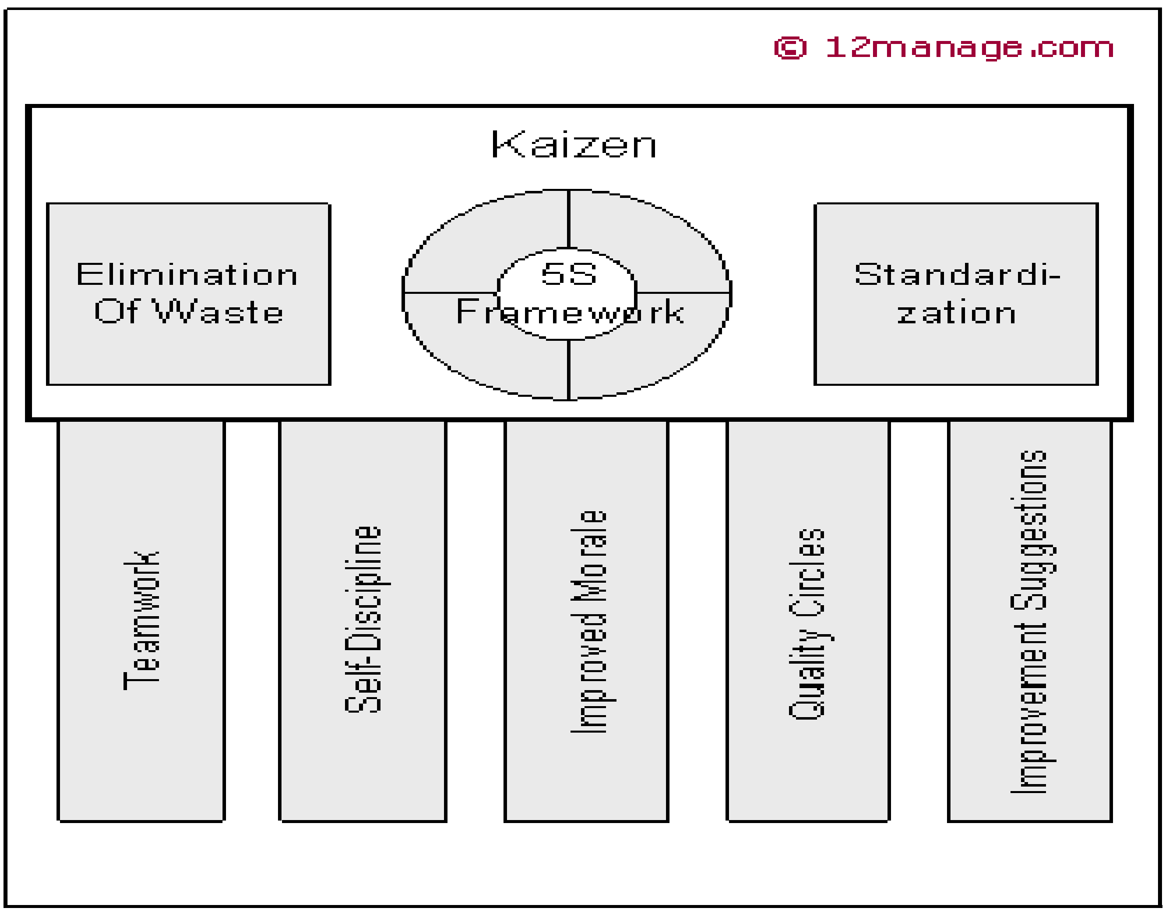


Figure 3.5: Building Kaizen Quality Management Team

3.11 Total Productive Maintenance (TPM)

TPM is a scientific company – wide approach in which every employee at every level in the organization is concerned about the maintenance, the quality and efficiency of their equipment.

A comprehensive system for reducing breakdowns and improving quality – by involving all employees in the elimination of waste of time and resources caused by production equipment [19].

3.12 POKA YOKE

Poka Yoke means Yokeru (avoid) Poka (mistake). Applying mistake proofing concepts to process or product improvements allow you to take a proactive approach to eliminating errors at their source before they become defects. Sorts "Good" from "Bad" practices / services, reduces problems before they are seen by customers, does not stop source of problems, does not prevent work defects, and does not prevent defects from getting to the customer, feedback very slow, often non-existent.

3.13 Lean Manufacturing Benefits

Organized and 'visual' workplace, Lower space/facility requirements, Improved use of floor space, Allows more strategic management focus, Improved knowledge retention, New employees fit in more quickly with less training, Cross-trained employees, Flexible work cells with flexible people, Small batch operations more cost effective, Productivity / Capacity increase, Inventory reduction, Cost reduction, Improved efficiency, Improved communication, Improved profit margins, Improved customer relations, Quality improvement, Improved vendor support and quality, Higher labor efficiency and quality, Reduced scrap and waste, Reduced cycle time, Reduced obsolescence, High quality and reliability, Lower overall costs, Self-directed work teams, Lead time reduction, Fast market response, Longer machine life, Improved flexibility in reacting to changes, Increased shipping and billing frequencies [20].

CHAPTER FOUR

VALUE STREAM MAPPING

4.1 Introduction

Value stream mapping (VSM) is the visual representation or documentation of the flow of information material, or people from receipt of customer order to delivery of finished product. It can be applied in manufacturing industries as well as service industries. This chapter gives an overall idea about value adding activity, non-value adding activity and necessary non value adding activity. This chapter also shows various symbols that are used to develop a Value Stream Mapping of a production process and finally discusses about the steps of producing Value Stream Mapping.

4.2 Value Stream Mapping (VSM)

A value stream is all the actions (both value added and non-value added) currently required to produce a product and analyze the current material and information flow necessary through the input to output [21]. It is also a technique for creating “one page picture” of all the processes that occurs in a company. Companies are experiencing intense competitive pressure due to globalization; hence they cannot afford to operate with wastes in their processes [22]. It’s a sophisticated flow charting method that uses symbols, metrics, and arrows to help visualize processes and track performance. This method helps determine which steps of a process add value and which do not. Value Stream Mapping (VSM) is the process of mapping the material and information flows for components and sub-assemblies in a value chain from raw material to the customer. Womack and Jones (1996) define VSM as a tool, which allows identify ways to get material and information to flow without interruption, improve productivity and competitiveness, and help people implement system rather than isolated process improvements. Womack & Jones (1996), and Rother & Shook (1999) described value-stream maps as “material and information flow maps”, which are one-page diagrams showing the processes used to make a product. VSM is used to identify the sources of waste in the value stream as basis for implementation plan that helps to see and focus on flow with a vision of and ideal. In a lean improvement initiative, most of the improvement comes from squeezing out a large number of non-value-added steps. In the process, the value-added time can also be reduced [10].

The goal of VSM is to identify, demonstrate and decrease waste in the process. Waste being any activity that does not add value to the final product, often used to demonstrate and decrease the amount of ‘waste’ in a manufacturing system. VSM can thus serve as a starting point to help management, engineers, production associates, schedulers, suppliers, and customers recognize waste and identify its causes. As a result, Value Stream Mapping is primarily a communication tool, but is also used as a strategic planning tool, and a change management tool.

The process usually includes the physically mapping of the "Current State" while also focusing on where you get to, or the "Future State" map, which can serve as the foundation for other Lean improvement strategies. Somehow, a fundamental limitation of VSM is that it is a manual method for mapping and analysis of the flows of products, materials, people, information, etc. in manufacturing facilities [23].

The concept of a value stream borrows from Michael Porter’s Value Chain framework. The value chain is a model that helps analyze specific activities through which firms create value and competitive advantage. By locating the value creating processes next to one another and by processing one unit at a time, work flows smoothly from one step to another and finally to the customer. This chain of value-creating processes is called a value stream. A value stream is simply all the things done to create value for the customer. It requires identifying all steps necessary to design order and produce the product across the whole value stream, to highlight non-value adding waste. The whole value stream covers processes from ordering raw materials to delivery of the finished product to the customer.

Value Stream Mapping is a pencil and paper tool that helps you to see and understand the flow of material and information as a product makes its way through the value stream. The meaning is simple: Follow a product’s production path from customer to supplier, and carefully draw a visual representation of every process in the material and information flow. Then ask a set of key questions and draw a “future state” map of how value should flow [14].

In Lean Manufacturing, the value of a product is defined solely based on what the internal & external customer actually requires and is willing to pay for. Production operations can be grouped into following three types of activities:

4.2.1 Value Adding Activity

Value-added activities are activities which transform the materials onto the exact product that the customer requires, or those activities that, in the eyes of the end customer, make a product more valuable. A value adding activity is simple to define; it results in something that customer would pay for. It include the operation like conversion of input into useful end product.

4.2.2 Non-Value Adding Activity

Non-value-added activities are the activities that aren't required for transforming the materials into the product that the customer wants. Anything which is non-value-added may be defined as waste. Anything that adds unnecessary times, effort or cost is considered non-value-added. Another way of looking to waste is that it is any material or activity for which the customer is not willing to pay. Testing or inspecting materials is also considered as waste since this can be eliminated in so far as the production process can be improved to eliminate defects from occurring.

4.2.3 Necessary Non-Value Adding Activity

Those activities that, in the eyes of the end customer, do not make a product more valuable, but are necessary unless the existing supply process is radically changed. This type of waste is more difficult to remove in the short term and should be a target for longer term radical change. For example, high levels of inventory may be required as buffer stock, although this could be gradually reduced as production becomes more stable.

4.3 Steps of Value Stream Mapping

Value stream mapping is done in two steps.

a. Current state

A visual tool that documents the current condition of a manufacturing environment. A present-state value stream map captures all of the details of manufacturing processes just as they exist at the moment the map is produced, including any flaws or errors.

b. Future state

A visual tool that shows how a value stream can look after improvements have been implemented. A future-state value stream map is an ideal view of a value stream and represents the goal of a lean initiative.

Taking a value stream perspective means working on the big picture, not just individual processes, and improving the whole, not just optimizing the parts. Identifying the differences in the current and future states yields a roadmap for improvement activities [24].

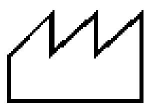
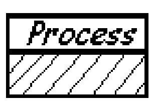
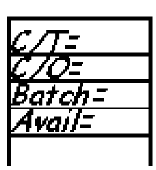
4.4 Value Stream Mapping Symbols

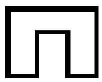
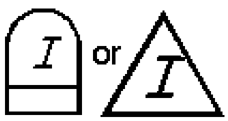
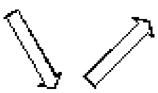
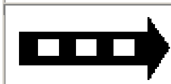
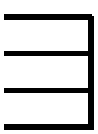
Numerous symbols are used in VSM to represent steps along the value stream path. Use the tools below to become acquainted with these symbols and how they can be used to illustrate processes. When mapping, focus should be horizontal across systems and departments, from order to delivery, not vertical in the departmental silo.

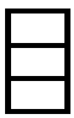
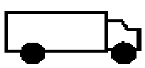
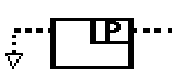
4.4.1 Symbols in VSM

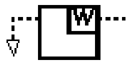
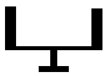
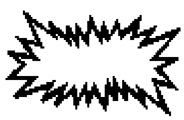
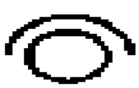
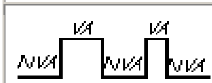
There are internationally recognized symbols for lean manufacturing to represent these value streams. At first we describe different symbols and their meanings-

Table 4.1: VSM symbol details

 **Customer/Supplier**	This icon represents the Supplier when in the upper left, the usual starting point for material flow. The customer is represented when placed in the upper right, the usual end point for material flow.
 **Shared Process**	This is a process operation, department or work centre that other value stream families share. Estimate the number of operators required for the Value Stream being mapped, not the number of operators required for processing all products.
 **Data Box**	This icon goes under other icons that have significant information/data required for analyzing and observing the system. Typical information placed in a Data Box underneath FACTORY icons is the frequency of shipping during any shift, material handling information, transfer batch size, demand quantity per period, etc. Typical information in a Data Box underneath MANUFACTURING PROCESS icons: C/T (Cycle Time) - time (in seconds) that elapses between one part coming off the process to the next part coming off, C/O (Changeover Time) - time to switch from producing one product on the process to another. Uptime- percentage time that the machine is available for processing. EPE (a measure of production rate/s) -

	Acronym stands for "Every Part Every___". Number of operators - use OPERATOR icon inside process boxes. Number of product variations, Available Capacity, Scrap rate, Transfer batch size (based on process batch size and material transfer rate)
 **Work cell**	This symbol indicates that multiple processes are integrated in a manufacturing work cell. Such cells usually process a limited family of similar products or a single product. Product moves from process step to process step in small batches or single pieces.
 **Inventory**	These icons show inventory between two processes. While mapping the current state, the amount of inventory can be approximated by a quick count, and that amount is noted beneath the triangle. If there is more than one inventory accumulation, use an icon for each. This icon also represents storage for raw materials and finished goods.
 **Shipments**	This icon represents movement of raw materials from suppliers to the Receiving dock/s of the factory. Or the movement of finished goods from the Shipping dock/s of the factory to the customers.
 **Push Arrow**	This icon represents the "pushing" of material from one process to the next process. Push means that a process produces something regardless of the immediate needs of the downstream process.
 **Supermarket**	This is an inventory "supermarket" (kanban stockpoint). Like a supermarket, a small inventory is available and one or more downstream customers come to the supermarket to pick out what they need. The upstream work center then replenishes stocks as required. When continuous flow is impractical, and the upstream process must operate in batch mode, a supermarket reduces overproduction and limits total inventory.

 **Material Pull**	Supermarkets connect to downstream processes with this "Pull" icon that indicates physical removal.
 **FIFO Lane**	First-In-First-Out inventory. Use this icon when processes are connected with a FIFO system that limits input. An accumulating roller conveyor is an example. Record the maximum possible inventory.
 **Safety Stock**	This icon represents an inventory "hedge" (or safety stock) against problems such as downtime, to protect the system against sudden fluctuations in customer orders or system failures. Notice that the icon is closed on all sides. It is intended as a temporary, not a permanent storage of stock, thus there should be a clearly-stated management policy on when such inventory should be used.
 **External Shipment**	Shipments from suppliers or to customers using external transport.
 **Production Control**	This box represents a central production scheduling or control department, person or operation.
 **Electronic Information**	This wiggle arrow represents electronic flow such as electronic data interchange (EDI), the Internet, Intranets, LANs (local area network), WANs (wide area network). You may indicate the frequency of information/data interchange, the type of media used ex. fax, phone, etc. and the type of data exchanged.
 **Production Kanban**	This icon triggers production of a pre-defined number of parts. It signals a supplying process to provide parts to a downstream process.

 **Withdrawal Kanban**	This icon represents a card or device that instructs a material handler to transfer parts from a supermarket to the receiving process. The material handler (or operator) goes to the supermarket and withdraws the necessary items.
 **Signal Kanban**	This icon is used whenever the on-hand inventory levels in the supermarket between two processes drops to a trigger or minimum point. When a Triangle Kanban arrives at a supplying process, it signals a changeover and production of a predetermined batch size of the part noted on the Kanban. It is also referred as “one-per-batch” kanban.
 **Kanban Post**	A location where kanban signals reside for pickup. Often used with two-card systems to exchange withdrawal and production kanban.
 **Go See**	Gathering of information through visual means.
 **Kaizen Burst**	These icons are used to highlight improvement needs and plan kaizen workshops at specific processes that are critical to achieving the Future State Map of the value stream.
 **Operator**	This icon represents an operator. It shows the number of operators required to process the VSM family at a particular workstation.
 **Timeline**	The timeline shows value added times (Cycle Times) and non-value added (wait) times. Use this to calculate Lead Time and Total Cycle Time.

At a glance necessary VSM symbols or icon.

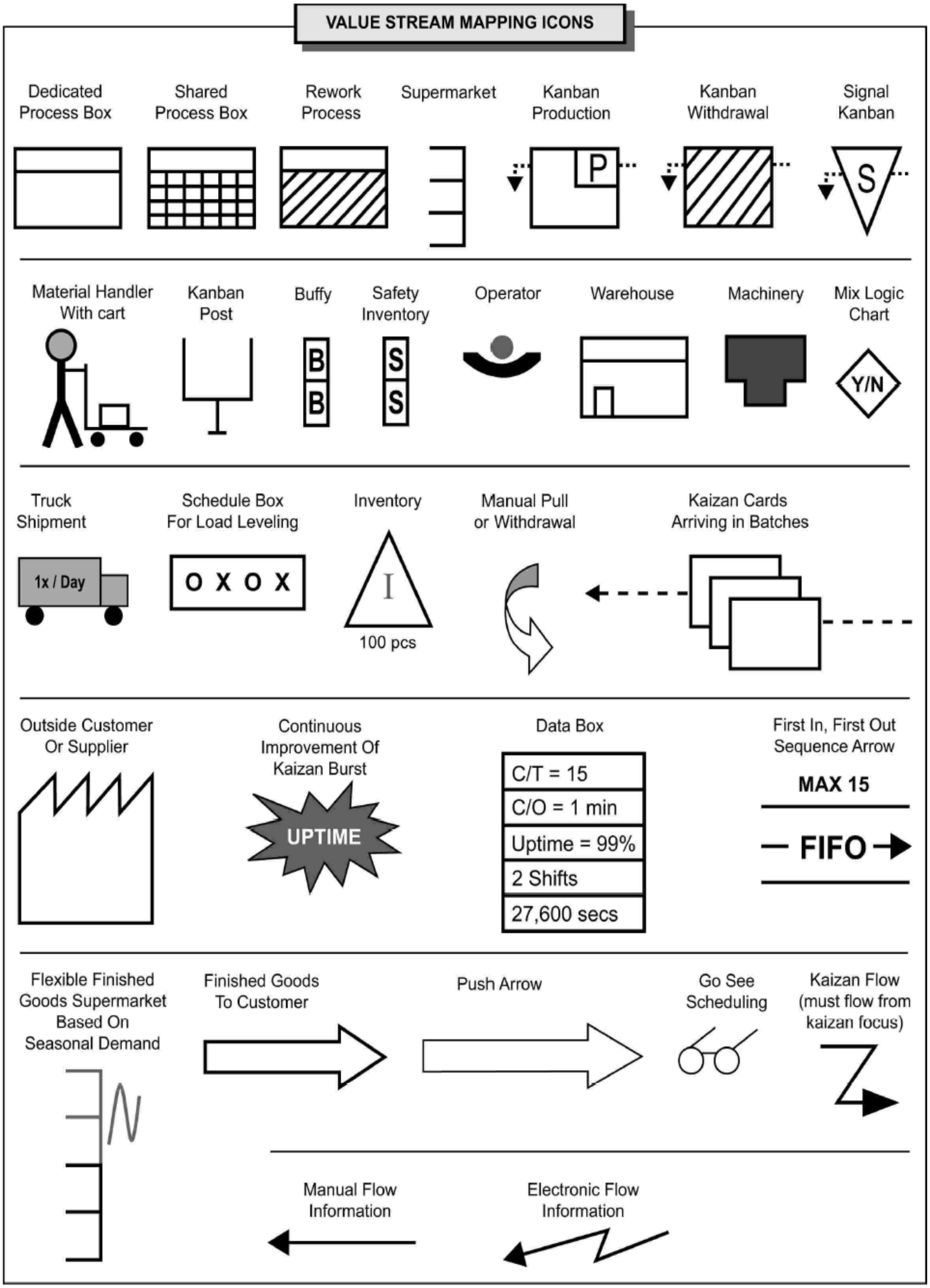


Figure 4.1: VSM symbols

4.5 Methods of Designing a Value Stream Mapping

According to Tapping and Shuker (2003) the steps of producing value stream mapping are following:

Step – 1: To begin with, draw the external (or internal) customer and supplier and list their requirements per month, e.g. in items, pieces, etc.

Step – 2: Next step is to draw the basic processes in the sequencing order in the value stream by listing the process attributes, i.e. Cycle time, changeover time, quantity of operators, available working time, etc.

Step – 3: Then, to draw queue times between processes, e.g. how many days or hours components wait until the next process.

Step – 4: The following step is to draw all communications that occur within the value stream, i.e. information flow.

Step – 5: And finally, to draw push or pull icons to identify the type of workflow, i.e. physical flow.

When mapping, focus should be horizontal across systems and departments, from order to delivery, not vertical in the departmental silo.

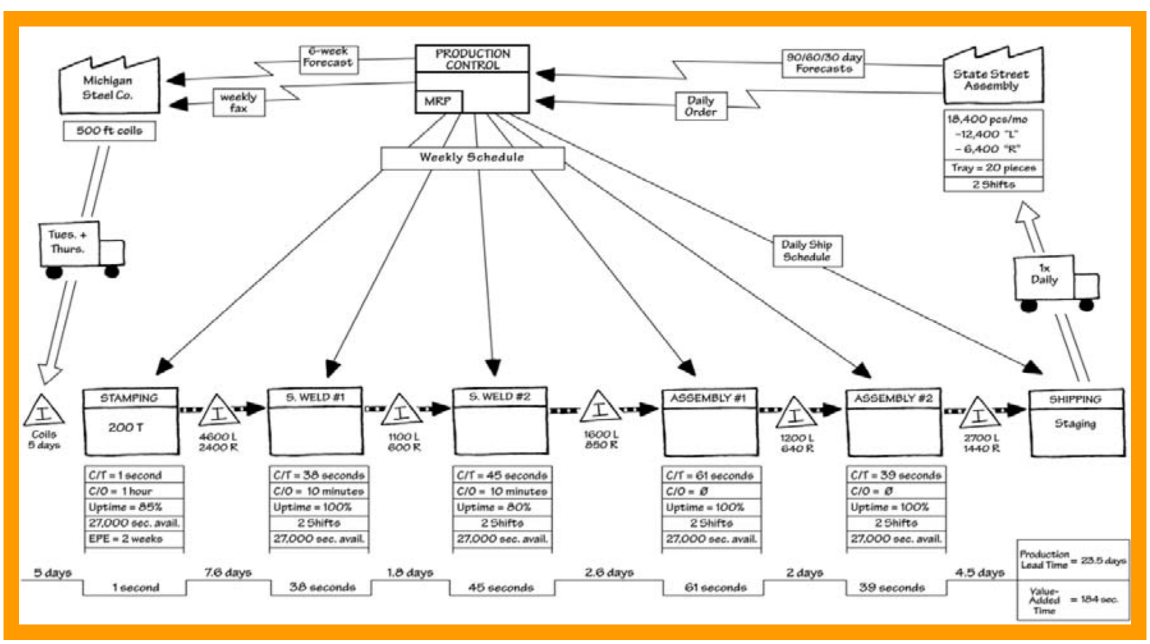


Figure 4.2: Example of Current state VSM

4.6 Importance of Value Stream Mapping

- It shows the linkage between the information flow and the material flow
- Creates a vision of the future by uncovering wastes and opportunities to create flow - and making them visible to all
- It helps visualize more than just the single-process level, i.e. assembly, welding etc.
- It ties together lean concepts and techniques and helps avoid “cherry picking”
- It makes decisions about the flow apparent, so easily can discuss them
- Prioritizes activities needed to achieve the future state
- Enables broad participation in shaping the future
- It forms the basis of an implementation plan
- It provides a common language for talking about manufacturing processes

It is much more useful than quantitative tools and layout diagrams that produce a tally of non-value added steps, lead time, and distance travelled, the amount of inventory, and so on.

CHAPTER FIVE

VSM CURRENT STATE MAP

5.1 Introduction

To eliminate waste first we have to develop a value stream for the current system. The Value Stream Mapping (VSM) is a visualization tool by this method we can easily identify the different value added and non-value added activities. It helps to understand and streamline work processes using the tools and techniques of Lean Manufacturing.

5.2 Methods apply for designing current state map

The first step is to draw the current state value stream mapping to take a snapshot of how things are being done now. To collect data for VSM, core team was trained on how to collect data and exercise was carried out to ensure that core team was capable to collect date accurately. Material flow related data was collected by physically following the material from cutting to sewing to finishing.

Following are the steps how current steps are drawn.

- First select the process of a product which we want to design the VSM
- Collect the information walk through and identify the main process (i.e. how many process boxes from store to delivery)
- Note the all data information
- Mention value added & non value added work
- Fill the data box about non value added & Value added work
- Mention non value added work- (cycle time, actual time, activities, defects, WIP, transport, waiting)
- Calculation & make a process chart of value added & non value added work
- Make a summary sheet percentage of value added & non value added

5.3 Value stream mapping data details

In Value Stream Mapping data boxes there are some data uses, which details are following

a. Actual time

The time need to transform or physical appearance change or value adding.

b. Availability time

The time a production line is available for production. Availability time is measured in seconds and does not include planned downtime like lunch periods and breaks.

c. Batch

A specific quantity to be produced. Batch-model assembly lines produce products in groups.

d. Cycle time

The period required to complete one cycle of an operation; or to complete a function, job, or task from start to finish. Cycle time is used in differentiating total duration of a process from its run time.

e. Changeover time

Changeover time is the non-value added time required to convert a setup for one product line to a setup for another product line.

f. Lead time

The amount of time it takes from the beginning of a project to the completion of a finished part, or from an order for a part and its shipment to a customer.

g. Uptime

The ratio of actual production time of a machine to the availability of time. Expressed as a percentage, uptime is calculated by dividing actual production time by the availability time.

h. WIP

Work in progress is a type of inventory that is currently in process and is measured by days.

5.4 Current State of Cutting, Sewing and Finishing

The current state map of cutting, sewing and finishing of a polo shirt has drawn by taking all necessary data of data log sheet (Appendix- A, B, and C). Also identified the value adding, non-value adding and unavoidable non value added activities. Following are the current state summary.

5.4.1 Current State of Cutting

Table 5.1**:** Current state Cutting summary

Cutting Current State	
Cycle Time (min)	412
Actual Time (min)	42
Workers	32
Quantity Outputs (pcs)	1100
Batch Size (pcs)	1100
Waste	
Transportations (feet)	330
Defects	
Waiting Time (min)	2853

Total value added time = 42 min

Total non-value added time = 2984 min

Total unavoidable time = 239 min

Total time = VA time + NVA time + UNVA time

= 42 + 2984 + 239 min

= 3265 min

Total Lead time = 3265 min

% of value added time= 1.29%

% of non-value added time= 91.39%

% of unavoidable non value added time= 7.32%

5.4.2 Current State of Sewing

Table 5.2**:** Current state Sewing summary

Sewing Current State	
Cycle Time (min)	15.99
Actual Time (min)	2.84
Workers	45
Quantity Output (pcs)	1040
No of Activities	74
Batch Size (pcs)	25
Available Time	480
Up time	100%
Productivity	2.89
Waste	
Change over	4.27
Transportations (feet)	191
Defects	118
Waiting Time (min)	944.84

Total value added time = 2.84 min

Total non-value added time = 944.84 min

Total unavoidable time = 12.01 min

Total time = VA time + NVA time + UNVA time

= 2.84 + 944.84 + 12.01 min

= 959.69 min

Total Lead time = 959.69 min

% of value added time = 0.30%

% of non-value added time = 98.45%

% of unavoidable non value added time = 1.25%

5.4.3 Current State of Finishing

Table 5.3: Current state Finishing summary

Finishing Current State	
Cycle Time (min)	5.24
Actual Time (min)	0.04
Workers	13
Quantity Outputs (pcs)	1100
No of Activities	13
Batch Size (pcs)	10
Available Time	480
Waste	
Transportations (feet)	102
Defects	
Waiting Time (min)	172

Total value added time = 0.04 min

Total non-value added time = 172.00 min

Total unavoidable time = 5.20 min

Total time = VA time + NVA time + UNVA time

= 0.04 + 172.00 + 5.20 min

= 177.24 min

Total Lead time = 177.24 min

% of value added time = 0.02%

% of non-value added time = 97.04%

% of unavoidable non value added time = 2.93%

5.4.4 Combined Current State map of Cutting, Sewing and Finishing

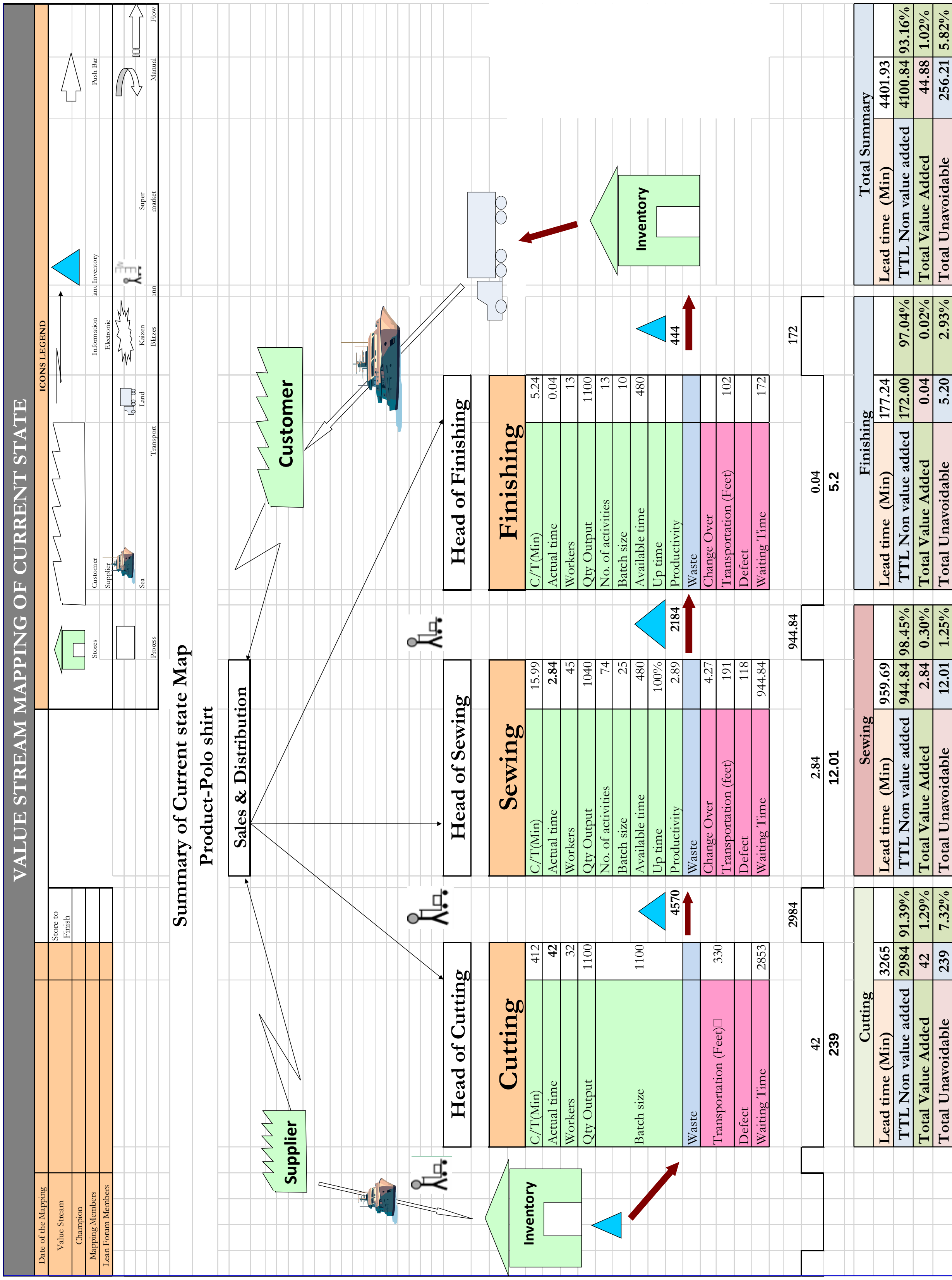


Figure 5.1: Summary of Current State Map

5.4.5 Result analysis of current state map

Total value added time = 44.88 min

Total non-value added time = 4100.84 min

Total unavoidable time = 256.21 min

Total time = VA time + NVA time + UNVA time

= 44.88 + 4100.84 + 256.21 min

= 4401.93 min

Total Lead time = 4401.93 min

% of value added time = 1.02%

% of non-value added time = 93.16%

% of unavoidable non value added time = 5.82%

5.4.6 Current value adding, non-value adding and unavoidable non value adding graph

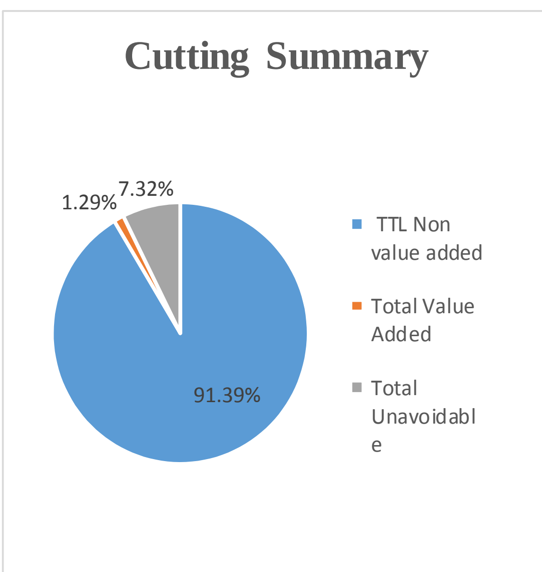


Figure 5.2: Cutting summary

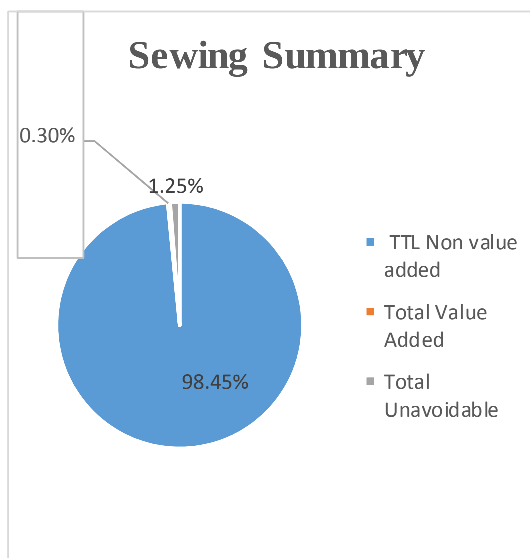


Figure 5.3: Sewing summary

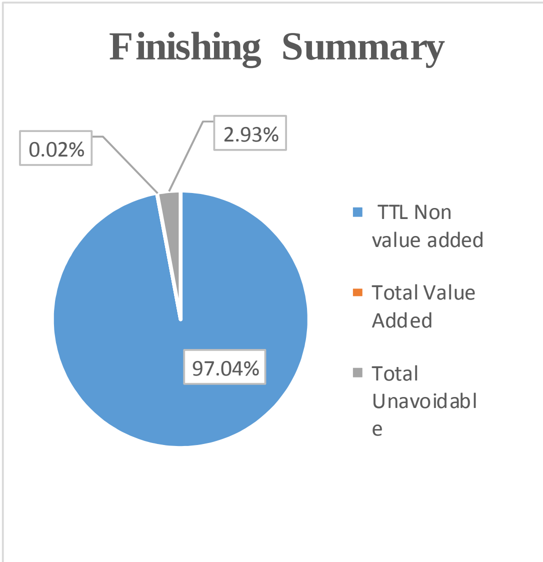


Figure 5.4: Finishing summary

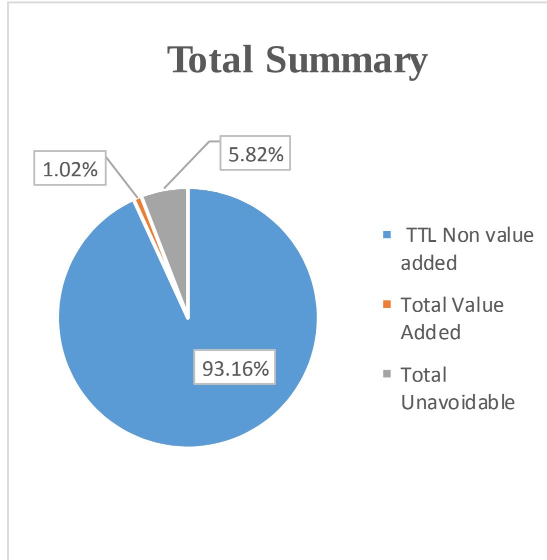


Figure 5.5: Total summary

5.4.7 Current Efficiency and Productivity graph of traditional lines

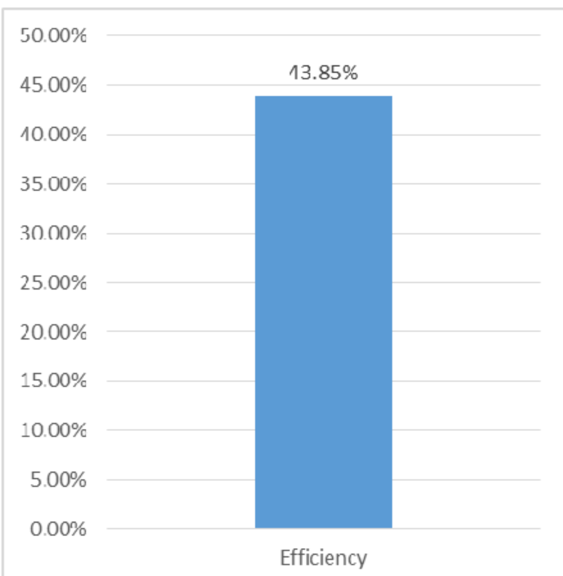


Figure 5.6: Current efficiency

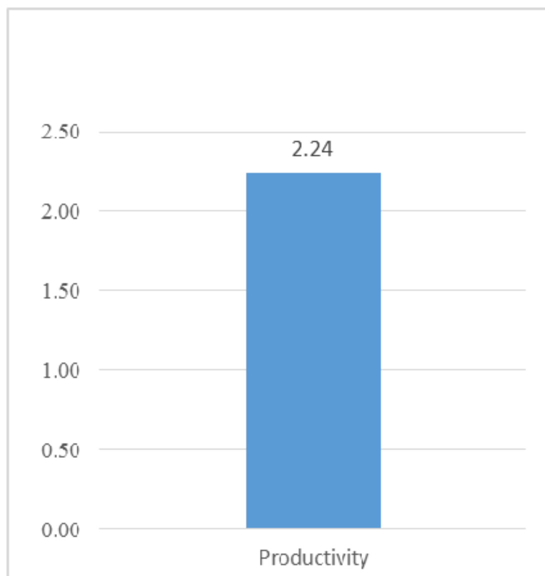


Figure 5.7: Productivity graph

5.4.8 Current Traditional line layout

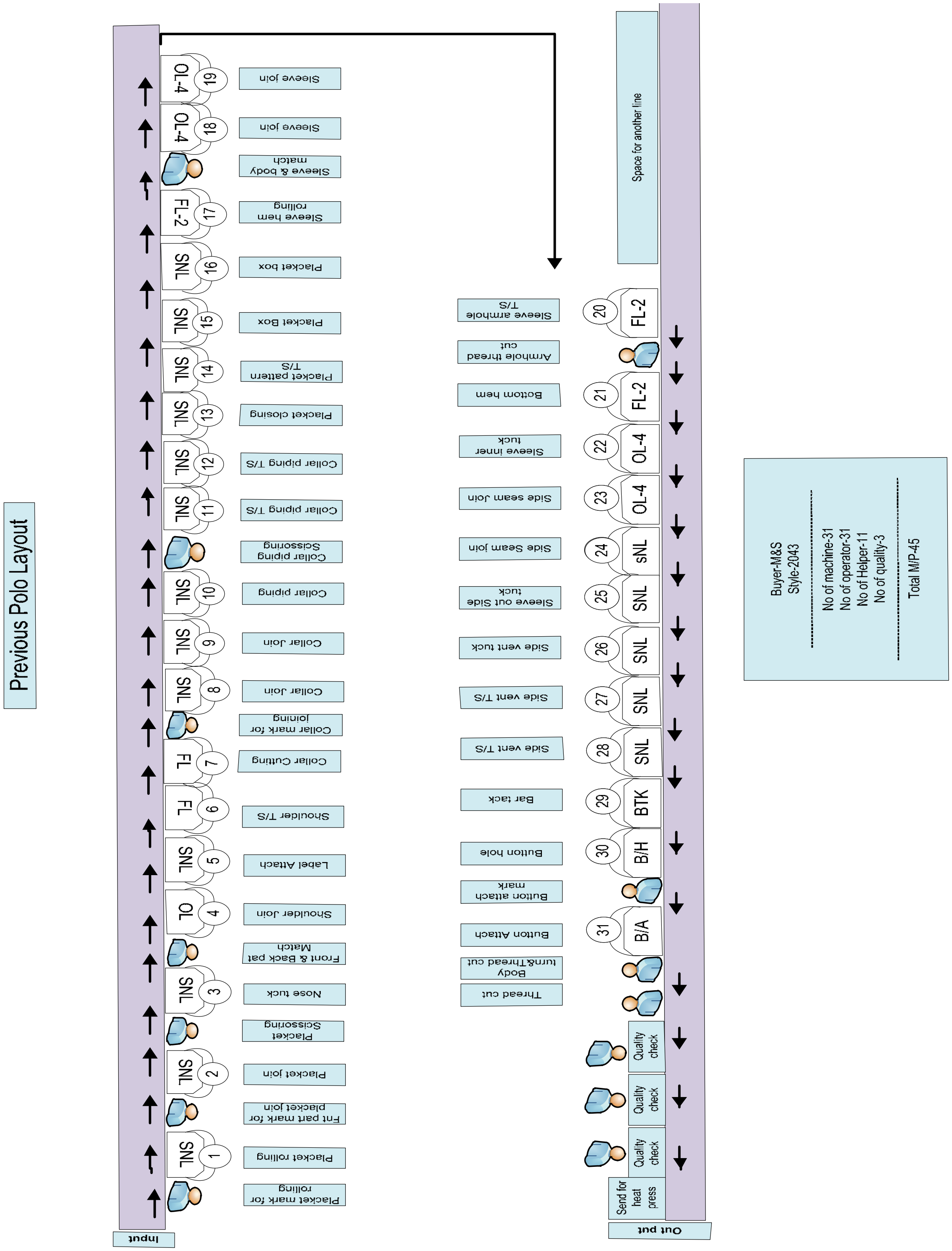


Figure 5.8: Current line layout

5.5 Improvement areas of Current State

5.5.1 Cutting section

- Fabric spreading time is too much for manual laying.
- After each laying fabric edge cutting by one scissor man.
- Using more helper for each laying
- Number is not starting from 1st stack of cutting
- Need helper for numbering
- Helper use for transportation in cutting place to numbering area
- Cuff collar cannot supply from cutting
- Input cannot control from cutting ultimate result is high WIP
- Using separate table for cutting, numbering, checking and bundling
- Properly not maintaining cut panel rack
- There is a transportation between cutting to sewing

5.5.2 Sewing section

a) Process

- Not multi-tasking practices
- Using helper for front and back match
- Using helper for body with sleeve match
- Helper using for placket, collar and button hole marking
- Surging of cuff and collar
- Don’t thread trimming by operator
- No bundle wise flow in sewing line from beginning to ending
- Less use of guide, folder and attachment
- Bundle pickup, dispatch and arranging system is not proper way i.e. disorganized way
- Do not use laser for marking
- Less Job sharing practices
- Not multi-machine operating by one worker
- Not machine cleaning by operator
- There is a transportation and waiting time from sewing to fusing section

b) Quality checking

- Each line QI 6 to 7 (3 for before iron and others for after iron)
- Not QI for inline quality check but one AQC for each two lines
- One for measurement check
- Not visualization of defects
- Measurement checking by normal measurement tape
- Two workstation for garments quality check

5.5.3 Finishing section

- Each line 7 to 8 person working (two for ironing and others for packing and folding)
- There is a transportation from sewing output to finishing and one guy is responsible for transportation.
- Don’t measurement sketch on iron table for this reason most of the time garments shape is not ok or measurement variation.
- Hang tag, folding, poly and barcode every process is doing by separate worker

CHAPTER SIX

FUTURE STATE MAPPING AND IMPLEMENTATION

6.1 Introduction

Value stream mapping is important to identify non value adding task and time. We can reduce non value adding activities by increase value adding activities through a future state mapping. All the activities which we will implement in future all are given in future state map.

6.2 Drawing Future State VSM

For designing a future a state map we have to prepare and begin actively using an implementation plan that describes, on one page, how to achieve the future state plan. The propose Future State VSM is drawn by showing different types of Lean concept of kaizen, process merging, job sharing, multitasking, multi-machine operating and operation change, reduce transportation on the improvement areas of Current State VSM. The Production unit needs to work with the required rate of production and to maintain the quality and efficiency also. Figure 6.1, 6.2, 6.3 is showing the future state mapping.

6.3 Future VSM implementation project team

After designing the future state map and implement the Kaizen Event and other improvements a project team has been formed and also design their regular task.

Table 6.1: Project team

Project Champion	Mr. Javed Iqbal
Project Manager	Mr. Moin Uddin,
Project Team Leader	Mr. Mahabub Alam, Mr. Hasan Ali
Execution Team member	Mr. Akter, Mr. Monibur Rahman, Mr. Homayun Kabir, Mr. Selim Reza,
Supporting Team member	Mr. Nuruzzaman, Mr. Moshiur, Mr. Tanvir

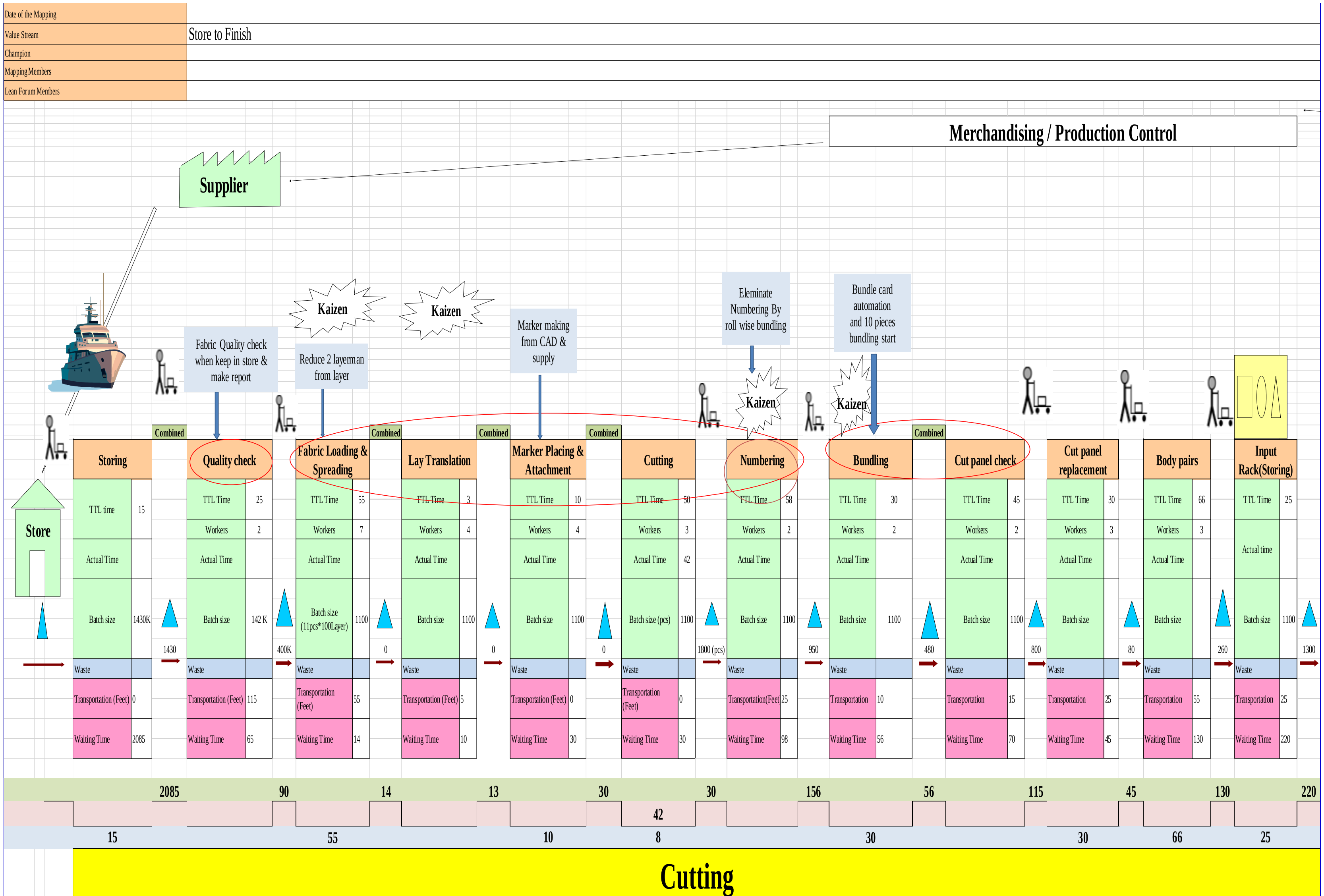


Figure 6.1: Cutting Future State Map

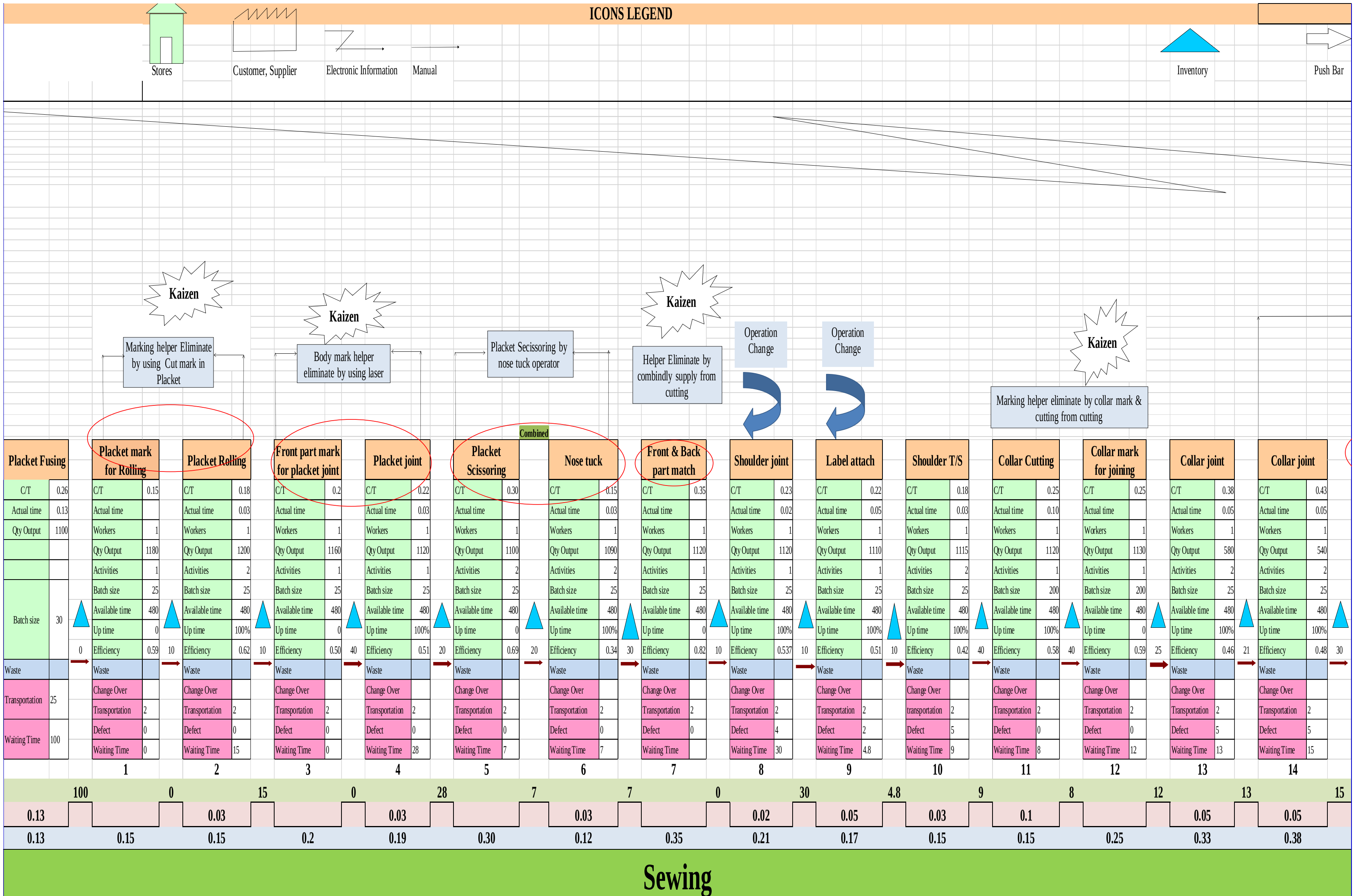


Figure 6.2(a): Sewing Future State Map

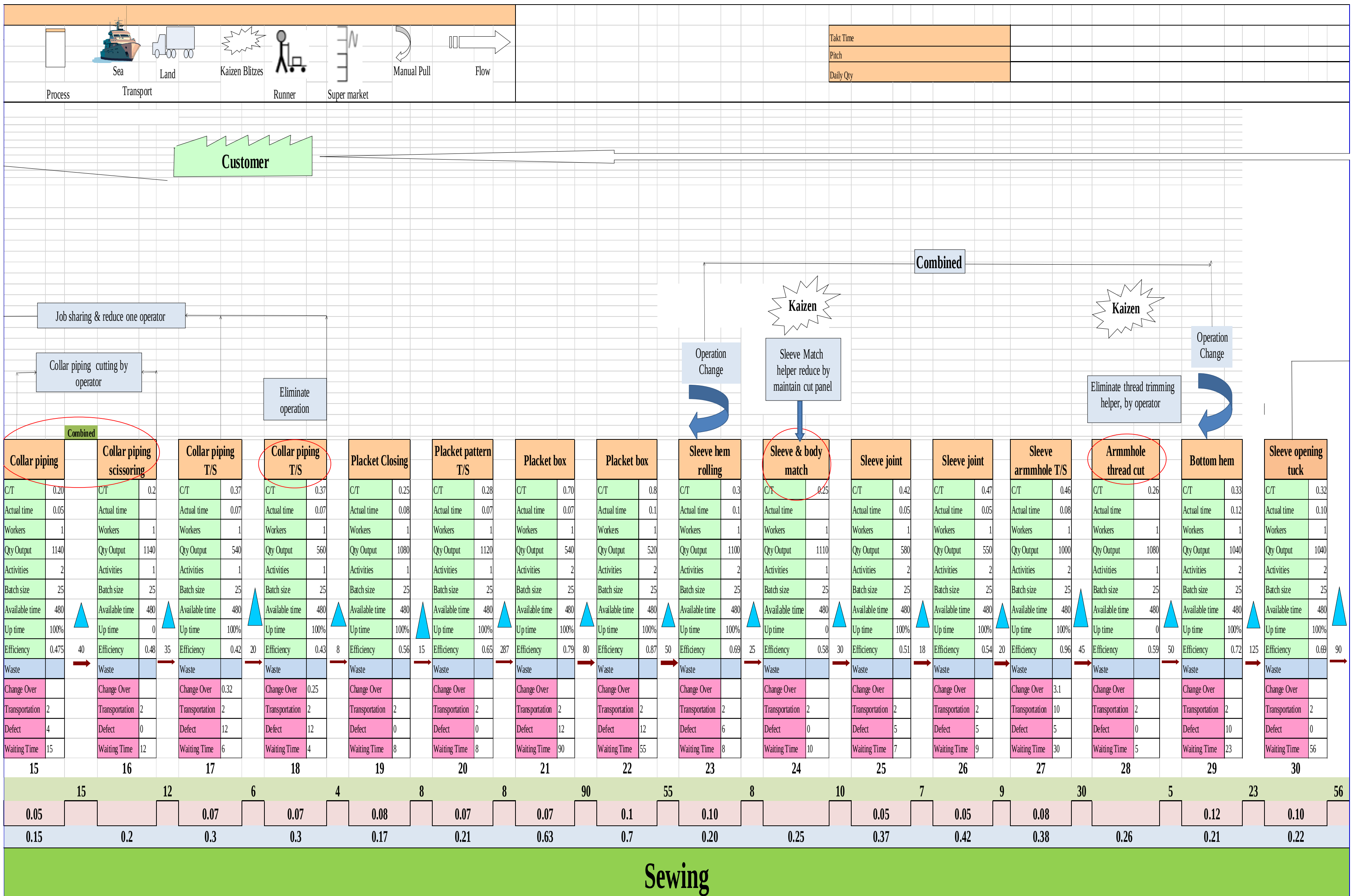


Figure 6.2(b): Sewing Future State Map

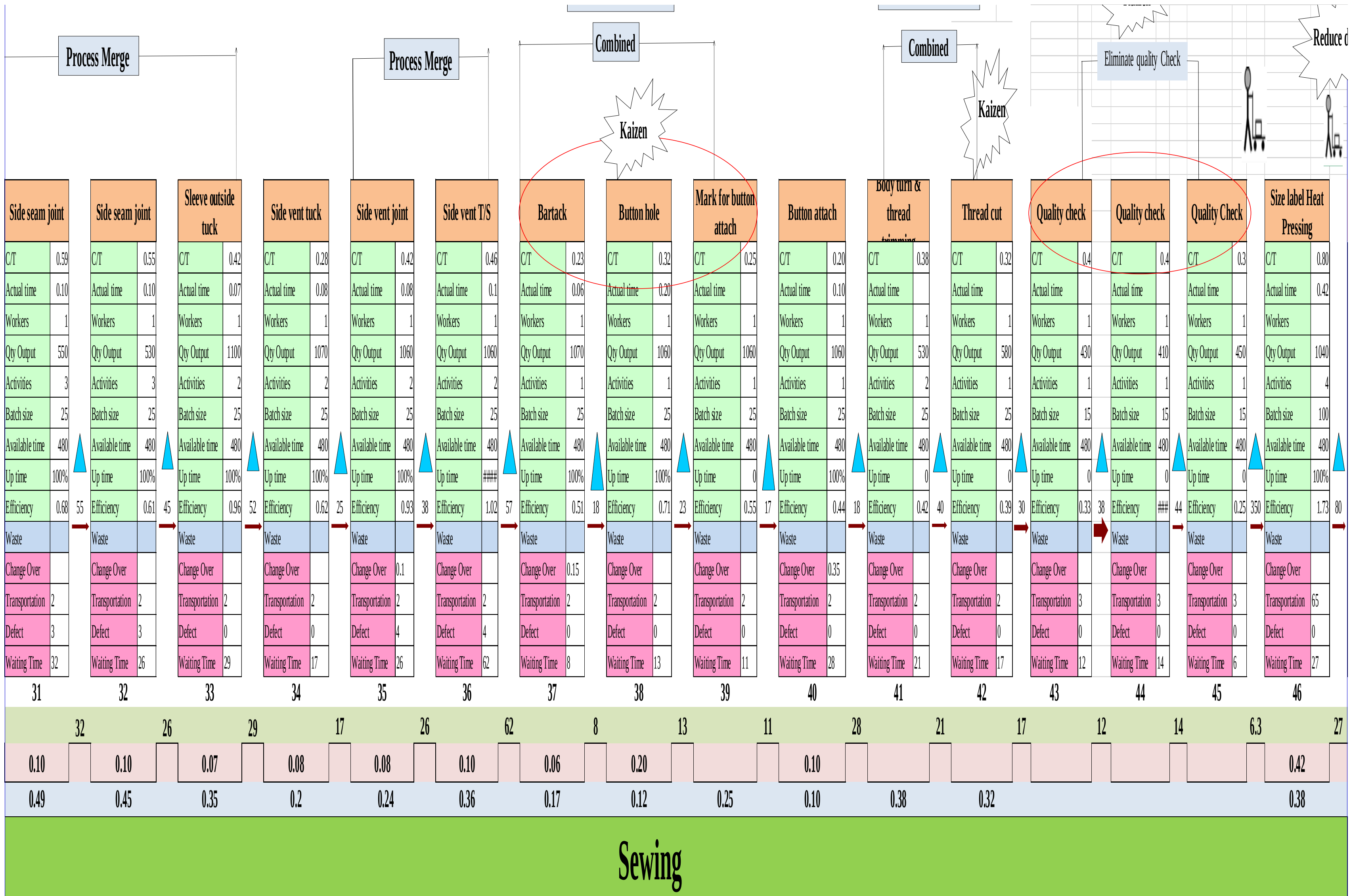


Figure 6.2(C): Sewing Future State Map

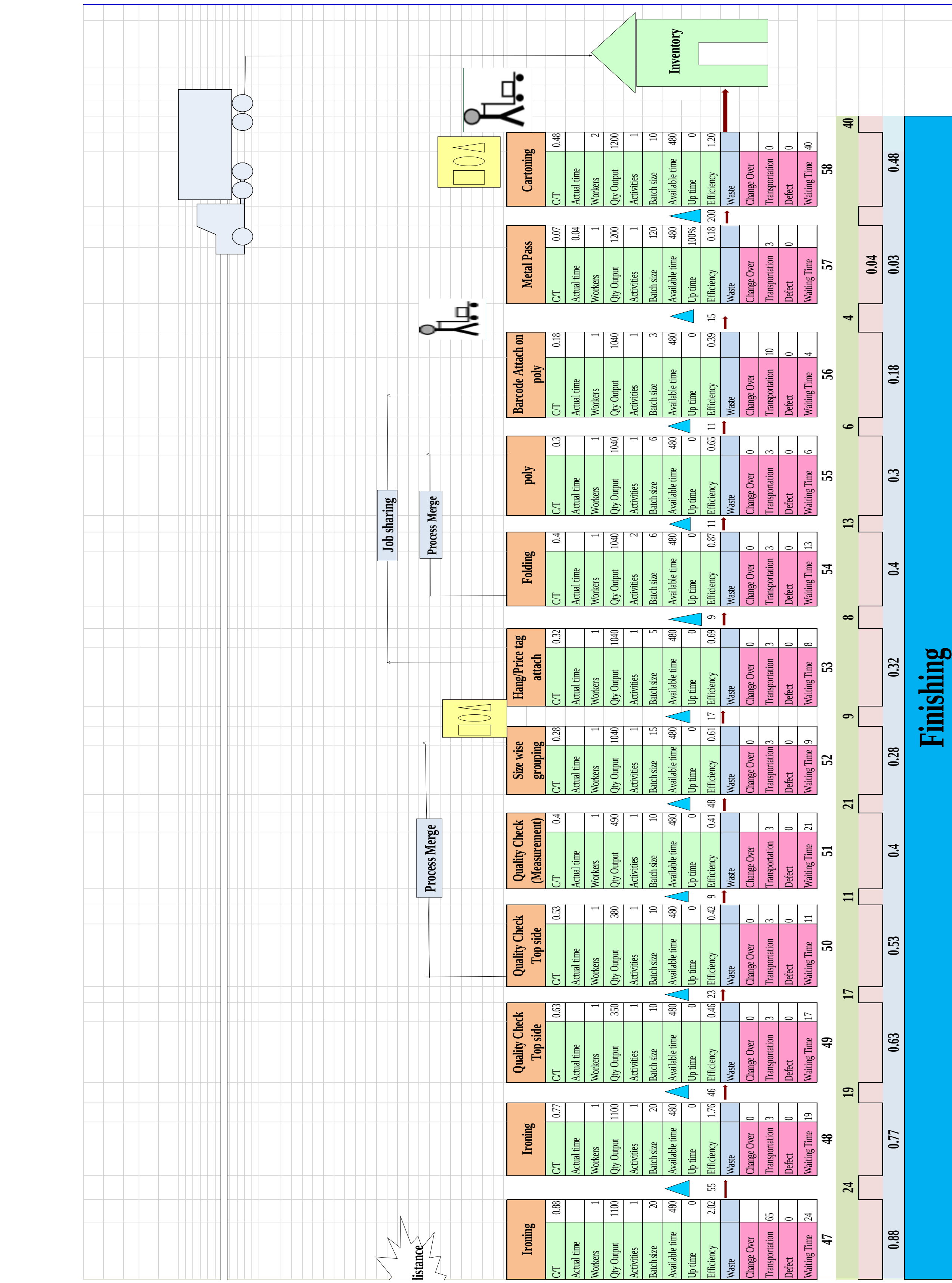


Figure 6.3: Finishing Future State Map

6.3.1 Responsibilities of Team

6.3.1.1 Project Champion Responsibilities

Champion is someone with the authority and the responsibility to allocate the organizations resources. The champion should possess the following attributes:

- A sense of Project ownership
- Authority to make change happen across functions and departments
- Authority to select the implementation core team
- Authority to commit resources

6.3.1.2 Project Manager Task

- Planning and Controlling and follow up the team
- Regular basis meeting with team
- Provide necessary guideline and direction
- Communication with project champion

6.3.1.3 Project Team Leader Task

- Communication with Team regular basis
- Give information to team according to project manager direction
- Regularly monitor and control project team
- Implement new good ideas other teams
- Create benchmarking for project products

6.3.1.4 Execution Team member Task

- Execution the new layout according to team leader direction
- Communication with production team regularly
- Motivation workers
- Logistics support (Guide, Folder arrangement)
- Regularly time study
- Skill matrix creation
- Productivity analysis daily basis
- Layout design and comparison
- Measure improvement daily basis

6.3.1.5 Supporting Team member task

- Capacity study and line graph make
- Production study
- Time study and cycle time check

- Hourly production follow up the team
- Record data before and after layout change
- Task comparison
- Take picture and video

6.3.2 Company profile

The selected apparel manufacturing plant is Viyellatex Ltd. Viyellatex is an export oriented knit garment manufacturing unit established in 1996. Now it is the ISO, Accord certified knit garments in Bangladesh. Main products are T-shirt, Polo Shirt, Trouser, Jacket and Fancy products etc. Currently it has 100 sewing lines in which most of the machines has auto trimmer and mostly oil-free dry head machine with the capacity of 2-2.5 million pieces. It is located at Sataish Road, Gazipura, Tongi Gazipur, Bangladesh. Viyellatex Ltd. has backward and forward linkage sister companies.

Table 6.2: Company Profile

Factory name:	Viyellatex
Factory address:	297, Khortoil, Tongi, Gazipura-1712, Bangladesh
Total direct labour:	5000 persons (Cutting, Sewing and finishing)
Product range:	T-shirt, Polo shirt, Jacket, Fancy product, Kids wear etc.
Sewing lines:	100 lines
Sewing operators per line:	For Basic-22, Semi Critical-32, Critical-48
Helpers per line:	Basic-8, Semi Critical-10, Critical-12
Daily working hours:	8
Selected product for mapping:	Polo shirt (Cutting, Sewing and Finishing)
Absenteeism:	5.5%
Days for order changeover:	23

6.4 Kaizen Events/Blitz

Traditionally, kaizen has meant making small, incremental improvements over a long period of time. A blitz is an intense and lightning-quick version of the kaizen process used to implement a variety of Lean techniques in a hurry, usually three to eight days in length. It is also sometimes called a Kaizen Event. It’s easy to understand why lean manufacturers are embracing the kaizen blitz. Improvement in a Lean organization must be an ongoing process and the structure of a kaizen blitz is one of the surest ways to augment continual change, increase efficiency and generate savings.

Following are the improvement ideas and implemented in Future state VSM.

6.4.1 Cutting Implementation

a. Team concept and training

Team building is important to achieve a goal. It is quiet impossible for one or two person to overcome and follow up a lots of process perfectly and nicely. As a result many people are engaged here to accomplish the task properly. So for team work need training and team building session that will help the people work together. Training is important to make the people knowledgeable about their task and responsibilities. By training we can easily adopt new concept and implement it.

b. Starting ten pieces bundling system

Traditional bundling system is more than twenty to thirty pieces in a one bundle. But our new concept is bundle is no more than ten pieces for tee shirt, polo shirt and five pieces for jacket product. If the bundle is small it will easy to handling and can easily arrange it.

Before Kaizen	After Kaizen
	

Figure 6.4: Ten pieces bundling

c. Maintaining serial in all ten pieces bundle to eliminate front with back and body with sleeve matching

In traditional system we can see that all time one or two person is engage for match front with back and body with sleeve. Now to reduce the helper we have to maintain serial in one bundle than we can easily match front, back and sleeve without any problem.

d. Start all parts in one bundle together such as front, back, and sleeve cut panel

In traditional system all parts are delivered as a separate bundle. As a result operator cannot find it easily and not interest to match it. So our new concept is we will deliver all parts suppose front, back and sleeve together also maintain serial from cutting.

e. Utilization of band knife machine for small parts cutting to keep dimensional accuracy

In current conditions people are not using band knife machine for small parts cutting. As a result the shape of the cut panel is not good. So our new concept for small piece cutting we cannot use normal straight knife cutter we will use band knife machine to keep small parts shape accuracy.

f. Start without numbering bundling system by implementing roll wise cutting system

Our new idea is from now we will not use sticker attach on cut panel we will cut the fabrics according to role wise and cannot amalgamate one role to another role if there are no shading issue may come. Because sticker is use only for shading purpose.

g. Maintain on time input of all parts

To reduce changeover and through time also non production time we will ensure that all parts are provided together and at a time.

h. Use same table for laying, cutting, checking and bundling to reduce transportation

To reduce transportation time on cutting section we will use same table for cutting numbering also check and bundling.

i. Elimination of bundle card writing helper by bundle card automation

Previously six to seven helper is engaged for bundle card writing and sometimes they cannot supply it quickly as urgent requirement. Now new concept, we will make it automation of paper printing (see appendix-L). As a result no need extra four to five helper.

j. Using light box for cut panel & fabric check

Traditional systems only fabric checking by light box but sometimes some cut panel problem cannot identified through normal light also some embroidery and print panel problem cannot identified. So if we use lighting box for checking cut panel it will more helpful for identified fabric defects quickly and accurately. As a result cutting defects will be reduced.

k. Uses of fabric edge cutter m/c after each laying

Traditional systems after each laying two scissor man cut the fabric with the help of scissor. But now our implement concept is we will use fabric edge cutter for each lay cutting. The following figure showing this-

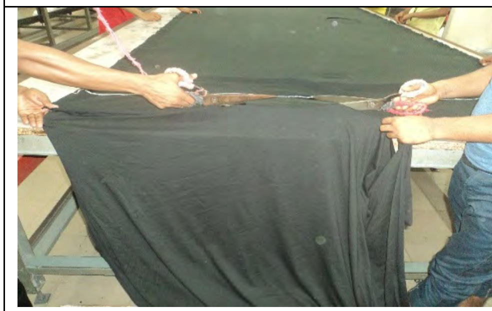
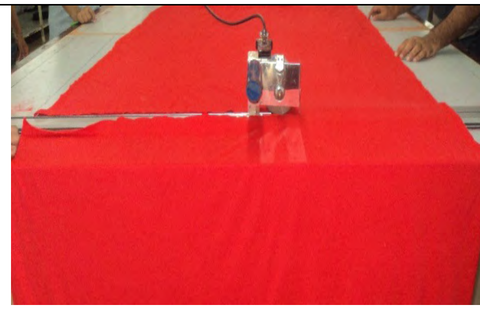
Before Kaizen	After Kaizen
	

Figure 6.5: Uses of fabric edge cutter after each lay

l. WIP control by providing daily basis input from cutting

Traditional systems there are no control of WIP. Cutting is providing all the cut panel what they have cut, but now our concept cutting will deliver only the daily basis requirement which is generated by planning. And by this way we can keep control sewing WIP.

m. Reduce layer man by using auto spreading machine

Traditional systems for fabric laying no spreader machine is using. But if we use spreader machine for each laying than we can easily reduce laying man for each table laying.

n. Reduce cutting transportation by keep cutting near sewing department

Traditional systems cutting is another floor or building for central cutting maintain. But it is not good for all times. If we keep the cutting near sewing we can easily communicate cutting problem and can solve the problem very quickly also reduce the transportation time and manpower. So our proposal is cutting should be near or parallel with sewing dept. it will be more effective for reduce cutting problem.

6.4.2 Sewing Implementation

Different types of improvement activities have been done in sewing section which are following:

6.4.2.1 Operator Reduction

a. Two machine operating by one operator

Normally one operator operate one machines but now one operator will operate two machines at a time. So we can easily reduce one operator from one machines, by process scanning.

b. Multi-tasking by one operator

Previously one person doing one task suppose operator is only operating machine but not thread cutting. Now our new concept is all worker will do two or three task at a time. For example each operator will be thread trimming after sewing and some operator will be marking and sewing at a time.

c. Job sharing

Previously operator cannot share the job. But now our target is one operator will share two process each hour, suppose half hour will do collar joint and another half hour will do another process collar top stitch.

6.4.2.2 Helper Reduction

Helper can be reduced by different ways following are some procedure also see appendix G.

a. ***Marking and thread trimming by operator***

In our project team we started new concept that every operator will be trimming their extra thread end after sewing, if we no need use extra helper for thread trimmings.

b. Elimination of matching through nicely arrange cut panel and all parts keep together in bundle

To reduce helper for front with back and body with sleeve, we will arrange the bundle serially and together and flow them together so for this reason we have no need extra two helper for front back match and body with sleeve match.

c. By using laser

Laser is now a popular technology in garments. By this we can easily reduce any marking procedure. For our model team we developed a laser system which will reduce placket and front body marking for placket joint. Here we will use two laser straight / line and cross laser.

Before Kaizen	After Kaizen
	

Figure 6.6: Use of laser for placket attach

6.4.2.3 Process Improvement

a. Use guide or folder or attachment

We have started use of guide and folder and attachment for better quality and keep two parts alignment parallel.

b. Cuff and collar cutting from cutting dept.

Previously we need two persons for collar marking and collar surging but now new concept is we will arrange the cuff and collar form cutting department. and both marking and surging by band knife machine. Finally we can easily reduce both two persons from sewing line.

c. Combined two process together

Sometimes one process capacity is low and another process capacity is high at that time if we combined two process together it will be balanced.

- Ex- Side vent tack & top stitch
- Ex-Opening tack & Chap tack
- Ex- lining & bone make together

d. Operation Change

Due to not proper operation balancing there is some transportation in the line so we have changed some operation at the end to beginning of the line in our project team.

e. Development of thread cutting table

Traditional system thread cutting is doing by normal flat table. For our project team we have developed a table where table top will be hole, and this hole will help to fall down the thread into down word and it has developed due to lose thread is one kind of defects which is not acceptable in quality inspections.

Before Kaizen	After Kaizen
	

Figure 6.7: Developed thread cutting table

6.4.2.4 Reduce WIP

a. Properly job distribution and line balancing

To reduce WIP it is important properly work distribution. Without proper work balance there will be a bottleneck and it will create the WIP. So from the line balancing graph we have to properly balancing the graph.

b. Keep 10 pieces bundling system

If twenty five or more pieces keep in one bundle it will create WIP in lines. Lean concept is single piece flow in assembly line and if we cannot do this we have to keep it as much as low quantity. We observe in knit factory that production quantity is higher than others. For this small quantity bundle is difficult. So our target is to keep the bundle size minimum ten pieces, which will help us to maintain WIP minimum quantity level.

c. Maintain two bundle flow

Traditional system there are no control of bundle flow. For our project team we will maintain two bundle flow from the starting to ending. As a result we can control line WIP and can easily identify the bottleneck process also balance the line.

6.4.2.5 System development and Layout

a. Development of skill matrix

Skill matrix is a process and operator list chart which is categories into good, batter and best of different types of machine process. Then according to process categorization necessary operators are arrange which is called skill inventory and this inventory is keep up to date to find out a best operator for emergency crisis. To implement future state map there is a skill matrix has been made and skill inventory has done (See appendix- E, F).

b. Reduce changeover time or through put time

By arranging input and all types of machines and necessary guide and attachment before starting a new layout, also complete special requirement or comment at PP stage. As a result through put time and changeover time can be reduced easily.

c. For critical item make the layout preparation section & assembly section

For critical layout suppose Jacket or fancy item make the layout two portions. One is preparations section and another one is assembly section. Independent parts will make from preparations section and sometimes this line will help other line at a time. Then the parts will go to assembly line for complete the garments.

d. Small and zigzag layout system

Traditional layout was u-shape and straight flow. As a result there were some transportation and sometimes it was difficult to job share. But new concept is straight line and zigzag flow so transportation will be low and process can be easily shared. Following are new proposed layout-

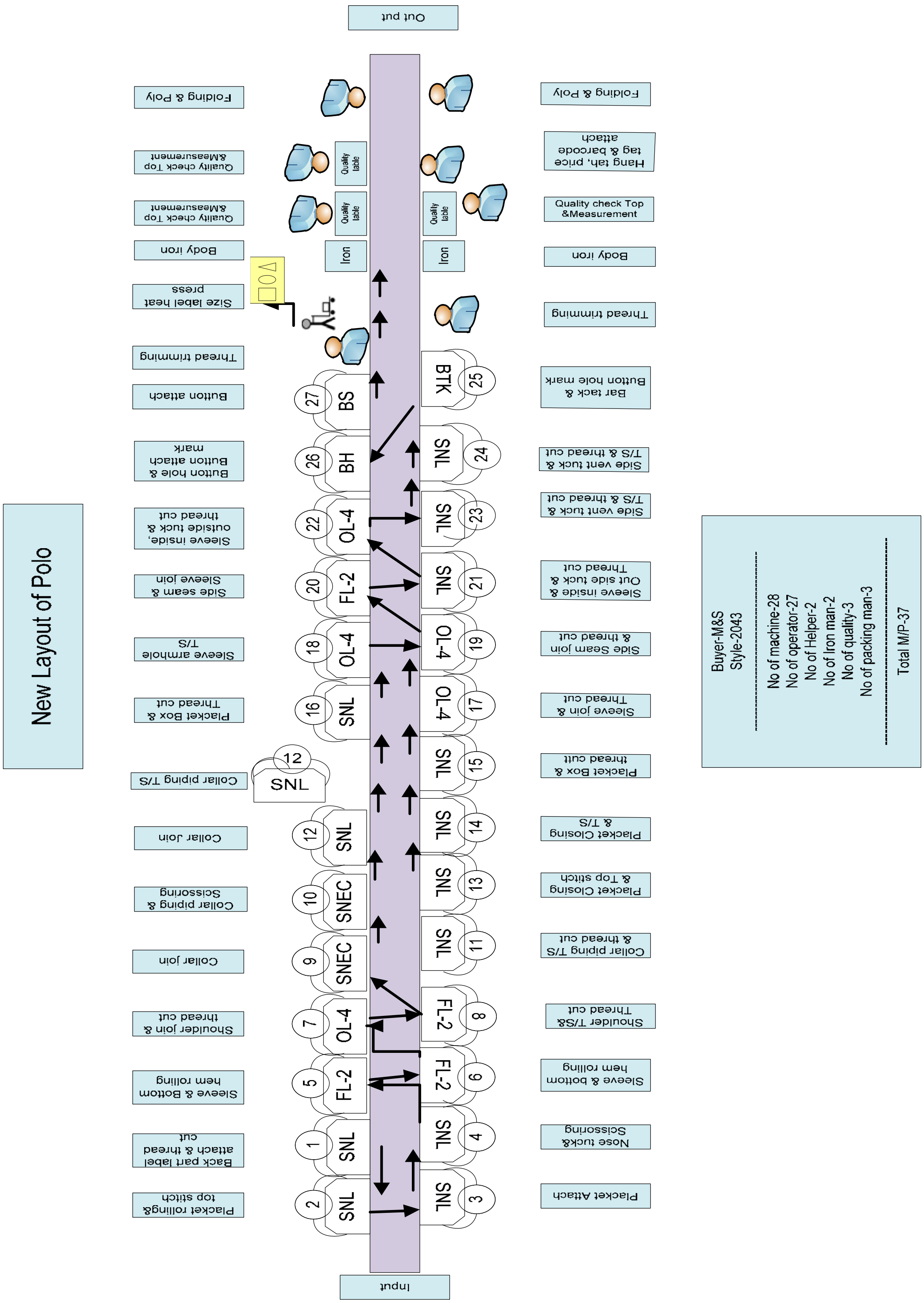


Figure 6.8: Proposed layout of sewing section

6.4.2.6 Synchronizations of production target

a. General target for sewing

Traditional system only target is given for sewing and for operator. So each hour later supervisor take all responsibilities to give the production.

b. Should be target for quality and Finishing also

New concept production target is not only for sewing but quality, and finishing also. Each hour later they have to take responsibilities to give the production. Otherwise there will be back log production to quality and finishing.

6.4.2.7 Quality implementation

a. ***Increase process QI by reducing table QI***

Traditionally all QI is working on table and one AQC is responsible for two lines, result is it is tough for him to monitor two lines at a time. If we increase line QI who will work on the inline critical process each hour. He will check all the critical process and share with production supervisor regularly. Following are developed in line quality process checking table.

Figure 6.9: New developed table for moving QI

b. ***Implementation of traffic light system***

It is a quality system designed to identify problems and get help from management to solve those problems. The purpose of this system is to identify quality problems within the needlepoint and to immediately give remedies to stop it from recurring.

The chart always starts with YELLOW and moves to either RED or GREEN but will never directly between RED and GREEN. In other words RED and GREEN are always separated by YELLOW.

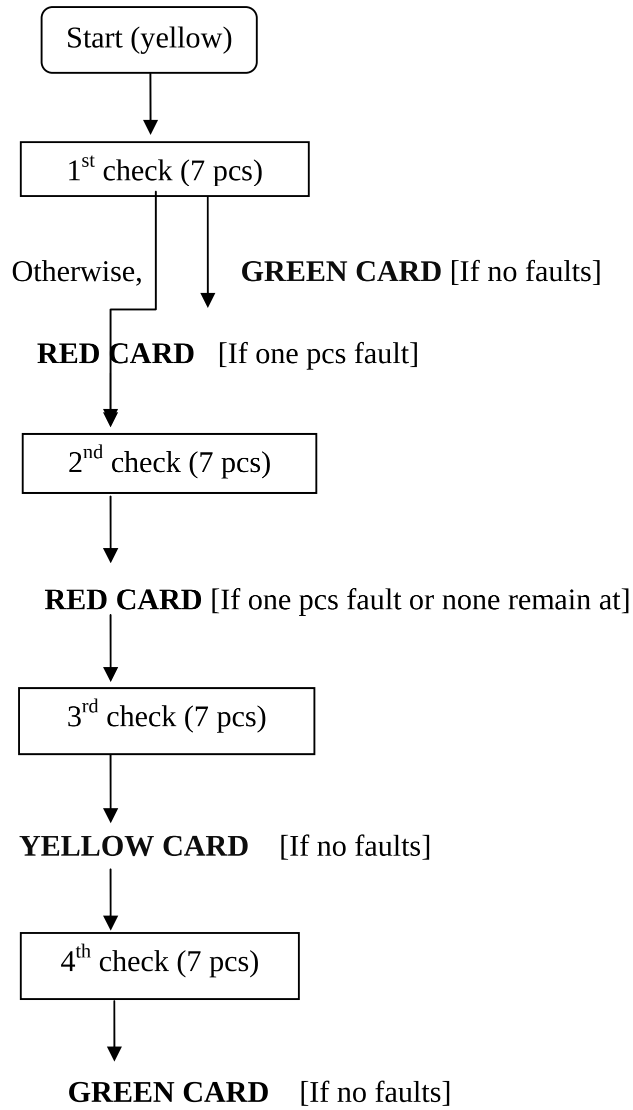


Figure 6.10: SOP of Traffic Light System for maintaining quality

c. ***Eliminate garments measurement by sketching measurement in QI table***

One QI is always responsible for check garments measurement. We can reduce it by drawing sketch on QI table. When the QI check the garments they will put the garments on the drawing sketch and easily can confirm the measurement. Following are some example-

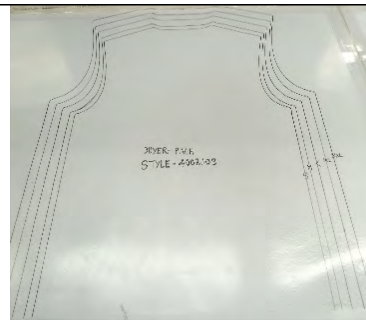
Before Kaizen	After Kaizen	
		

Figure 6.11: New concept of table quality checking procedure

d. ***To easily identification of defects and its locations using visual sketching of garments***

Visual management is good for take any decision. By this we can more easily take any types of decision. So if the QI put mark on sketch what they are finding in each checking. After complete the check they can easily identified where the problem locations and what is the frequency and which operator is responsible for this defects. They can share it with superior or operator and can solve it very quickly.

Before Kaizen	After Kaizen
	

Figure 6.12: Visualization of garments defects

e. ***After checking keep the garments size wise separately***

Sometimes one person is responsible for size wise garments grouping. But if we keep it separately size wise after checking and mark the table size wise then no need extra person for size wise grouping.

6.4.3 Finishing Implementation

a. ***Reduce transportation by integration of finishing with sewing output***

In traditional lines sewing and finishing section is separate for this there is a small transportation between them. Our new concept is sewing and finishing will merge together. Result is no extra transportation and waiting time between them and no need extra man for transportation. And if we can keep all the department near and parallel it will be more effective layout.

b. ***Folding and poly together (one for jacket, two for t- shirt & polo shirt)***

In traditional system one person is always engage for folding and one for poly but new concept is both two process is done by one person and ultimately there capacity will be equally utilized. Otherwise according to time study poly man capacity is more than folding man. As a result process will be merged.

c. ***Barcode and sticker attach by one person***

Traditional system one person is engage for bar code attach and another one for sticker attaching. But if we can do both task by one person it will be more effective.

d. ***For accurate shape of garments use marking on iron table***

In traditional system after completing the garments when iron man ironing the garments he has no idea about the garments shape. Result is measurement and shape is uneven and not exactly. But if we make a sketch on iron table it will be more helpful about the garments shape. When iron man ironing the garments he will keep the garments on the sketch it will be helpful to keep the garments its perfect shape also.

Before Kaizen	After Kaizen
	

Figure 6.13: Sketch on iron table

CHAPTER SEVEN

DATA ANALYSIS AND RESULTS

7.1 Introduction

A Future state map is generated based on the current state map to improve the value-adding time by eliminating the non-value adding time in the current system. To implement future state different types of kaizen has done and different initiative has taken. The process time is shortened by the proper follow up and motivation, delay time is removed by proper planning, controlling and the schedule is maintained with the help of all related and concerned people.

7.2 Data analysis

After implementation of different kaizen on current state following is the comparison between current and implemented future state, and for line balancing graph (see appendix D, and H).

Table 7.1: Comparison between traditional line and model line summary

Comparison Criteria	Traditional line	Model line
No of Machine	31	28
No of Operator	31	27
No of Helper	11	2
No of QI	6	3
No of Iron	2	2
No of Packing worker	8	6
Total worker	58	40
Quantity Output	1040	960
Avg. Working Hour	8	8
Avg. Hourly Production	130	120
Output Min	8840	8160
Input Min	20160	13920
Average sewing Efficiency	43.85%	58.62%
Productivity	2.24	3.00
No of Defects	118	20
WIP	2184	420
Process Integration or merge	0	7
Multi machine operating	0	1

7.3 Summary after Implementation of Future State map

After implementation of future state map following are the data and result analysis (See appendix I, J, K)

7.3.1 Future State of Cutting

Table 7.2: Future state Cutting summary

Cutting Future State	
Cycle Time (min)	271.26
Actual Time (min)	42.13
Workers	20
Quantity Outputs (pcs)	1100
Batch Size (pcs)	1100
Waste	
Transportations (feet)	135
Defects	
Waiting Time (min)	991

Total value added time = 42.13 min

Total non-value added time = 991.00 min

Total unavoidable time = 229.13 min

Total time = VA time + NVA time + UNVA time

= 42.13 + 991.00 + 229.13 min

= 1262.26 min

Total Lead time = 1262.26 min

% of value added time = 3.34%

% of non-value added time = 78.51%

% of unavoidable non value added time = 18.15%

7.3.2 Future State of Sewing

Table 7.3: Future state Sewing summary

Sewing Future State	
Cycle Time (min)	14.34
Actual Time (min)	2.50
Workers	29
Quantity Output (pcs)	960
No of Activities	62
Batch Size (pcs)	10
Available Time	480
Up time	100%
Productivity	4.14
Waste	
Change over	4.39
Transportations (feet)	146
Defects	20
Waiting Time (min)	318

Total value added time = 2.50 min

Total non-value added time = 318.00 min

Total unavoidable time = 11.87 min

Total time = VA time + NVA time + UNVA time

= 2.50 + 318.00 + 11.87 min

= 332.37 min

Total Lead time = 332.37 min

% of value added time = 0.75%

% of non-value added time = 95.68%

% of unavoidable non value added time = 3.57%

7.3.3 Future State of Finishing

Table 7.4: Future state Finishing summary

Finishing Future State	
Cycle Time (min)	5.30
Actual Time (min)	0.04
Workers	13
Quantity Outputs (pcs)	960
No of Activities	13
Batch Size (pcs)	10
Available Time	480
Waste	
Transportations (feet)	53
Defects	
Waiting Time (min)	123

Total value added time = 0.04 min

Total non-value added time = 123 min

Total unavoidable time = 5.26 min

Total time = VA time + NVA time + UNVA time

= 0.04 + 123.00 + 5.26 min

= 128.30 min

Total Lead time = 128.30 min

% of value added time = 0.03%

% of non-value added time = 95.87%

% of unavoidable non value added time = 4.10%

7.3.4 Combined Future State map of Cutting, Sewing and Finishing

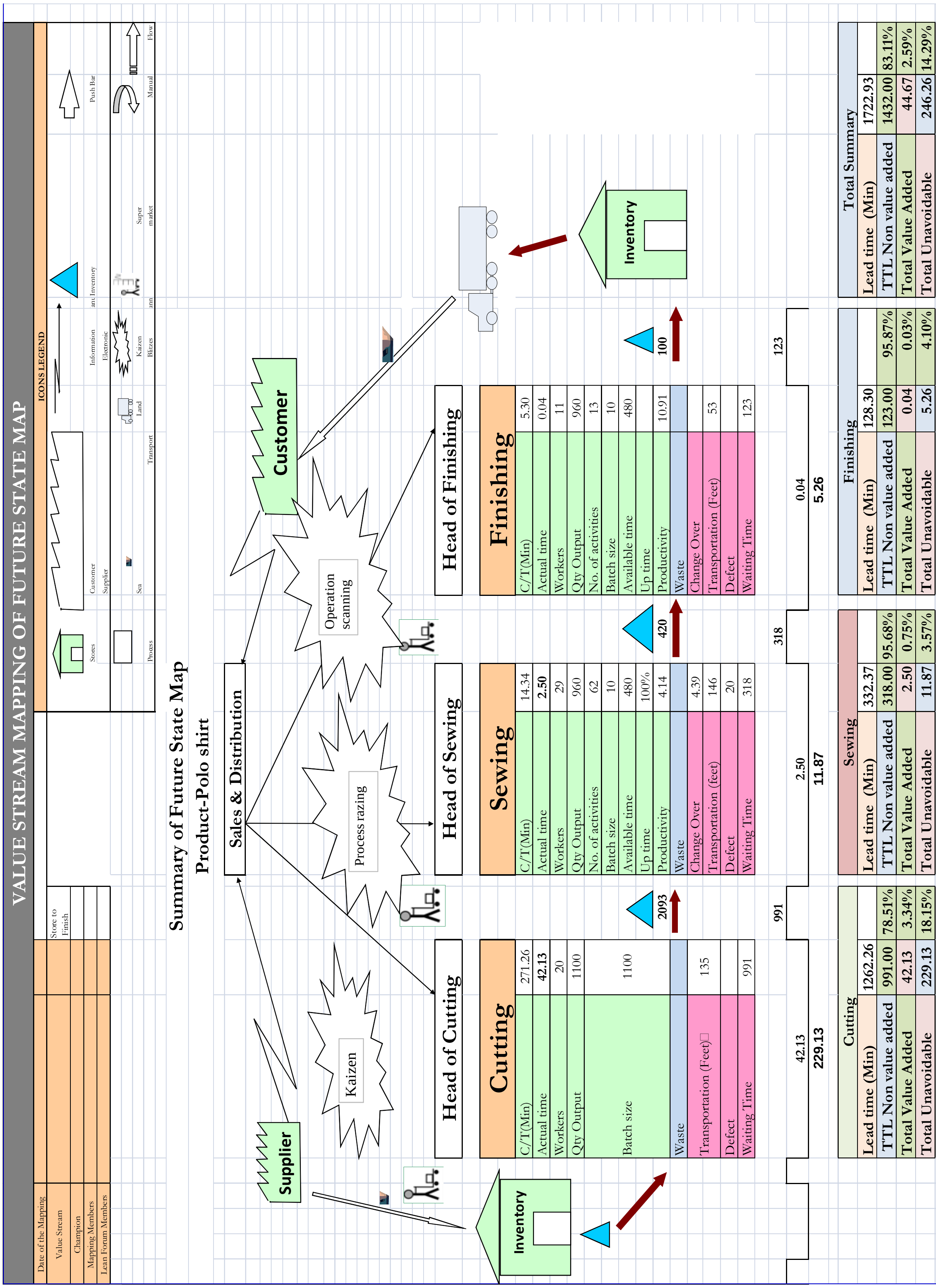


Figure 7.1: Summary of Future State Map

7.4 Result analysis of implemented future state map

Total value added time = 44.67 min

Total non-value added time = 1432 min

Total unavoidable time = 246.26 min

Total time = VA time + NVA time + UNVA time

= 44.67 + 1432 + 246.26 min

= 1722.93 min

Total Lead time = 1722.93 min

% of value added time = 2.59%

% of non-value added time = 83.11%

% of unavoidable non value added time = 14.29%

Following are the implemented future state map value adding, non-value adding and unavoidable non value adding time summary:

Table 7.5: Summary of implemented future state map

Criteria	**Implement Future State Map**	
	Time	Percentage
Lead time (min)	1722.93	
Non Value adding time	1432.00	83.11%
Value adding time	44.67	2.59%
Unavoidable non value adding time	246.26	14.29%

Following are the future state map cutting, sewing, finishing and total summary graph:

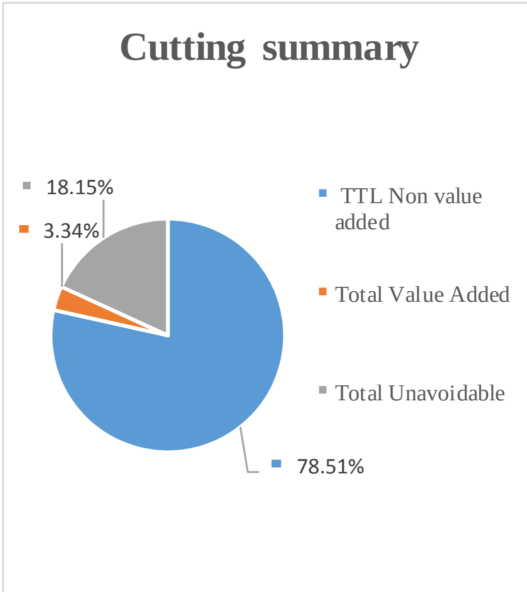


Figure 7.2: Future state Cutting summary

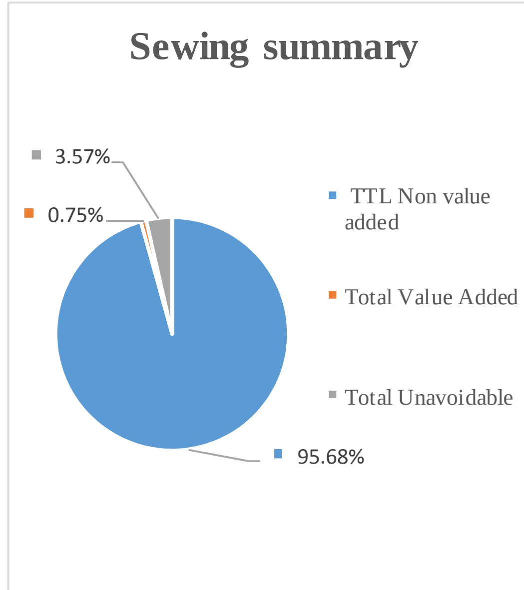


Figure 7.3: Future state Sewing summary

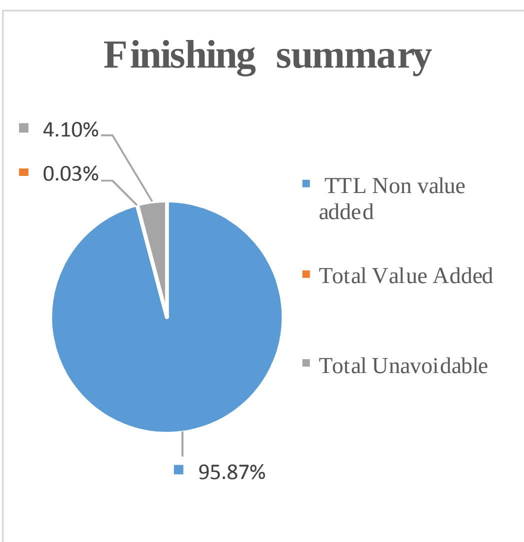


Figure 7.4: Future state Finishing summary

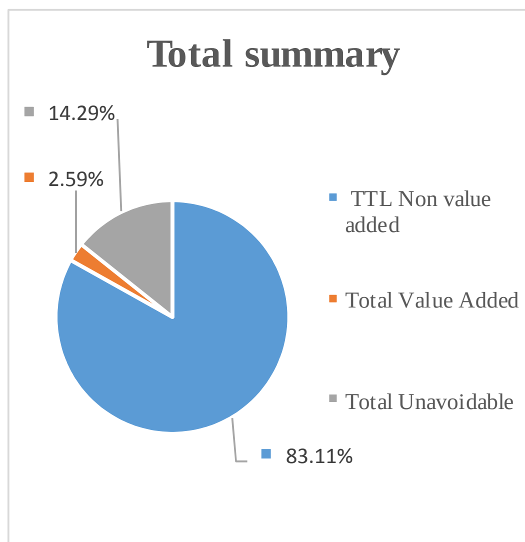


Figure 7.5: Future state Total summary

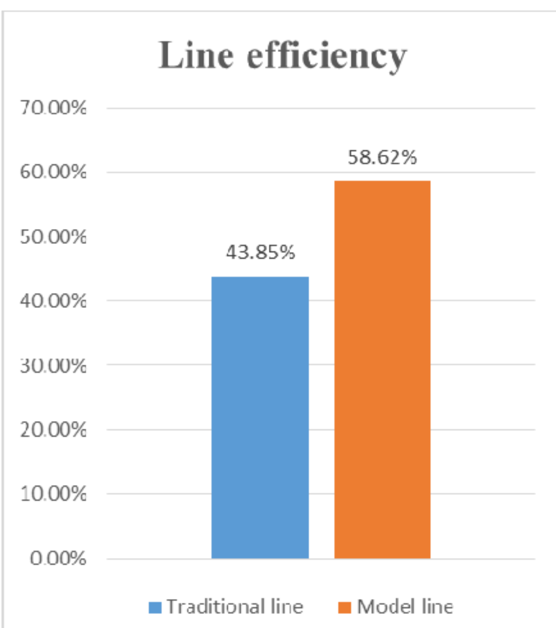
7.5 Final Results

Following are the final comparison between traditional line vs model line-

Table 7.6: Comparison between traditional and model line

Performance measure	Unit of Measurement	Traditional line	Model line	Improvement percentage
Line efficiency	Percentage	43.85%	58.62%	33.68%
Line productivity	Labour per hour (pcs)	2.24	3.00	33.92%
WIP reduction	Pieces	2184	420	80.76%
Lead time reduction	Percentage	4401.93	1722.93	60.85%
Value adding time increased	Percentage	1.02%	2.59%	153.92%
Non value adding time reduced	Percentage	93.16%	83.11%	10.78%

Following are the traditional and model line efficiency, productivity, WIP, lead time, value adding, and non-value adding time comparison graph:



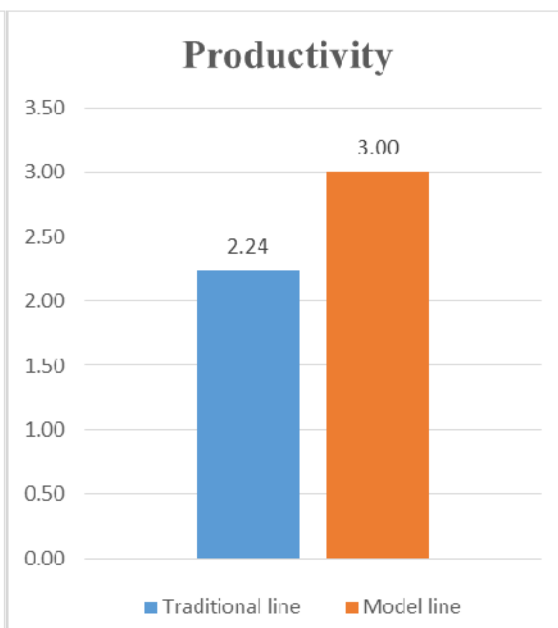


Figure 7.6: Comparison of line Efficiency

Figure 7.7: Comparison of Productivity

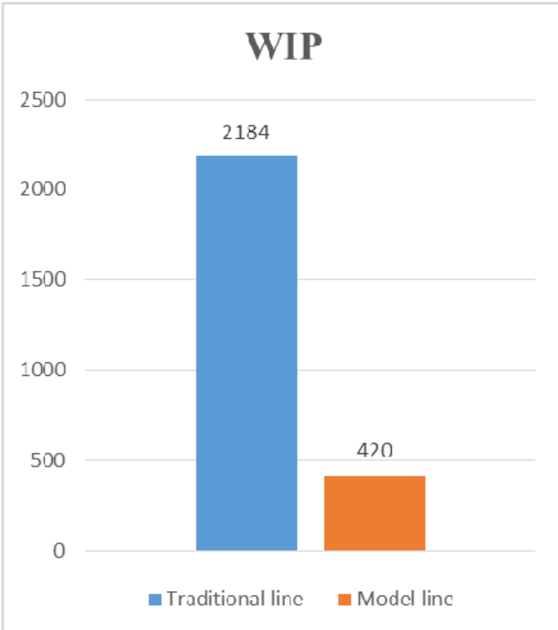


Figure 7.8: Comparison of line WIP

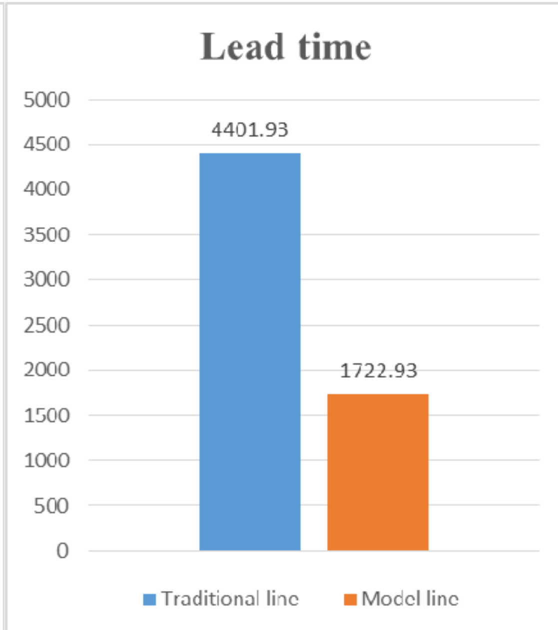


Figure 7.9: Comparison of Lead time

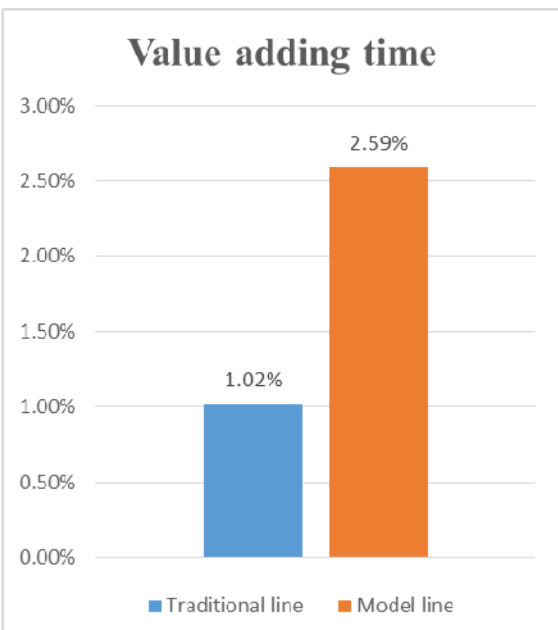


Figure 7.10: Comparison of Value adding

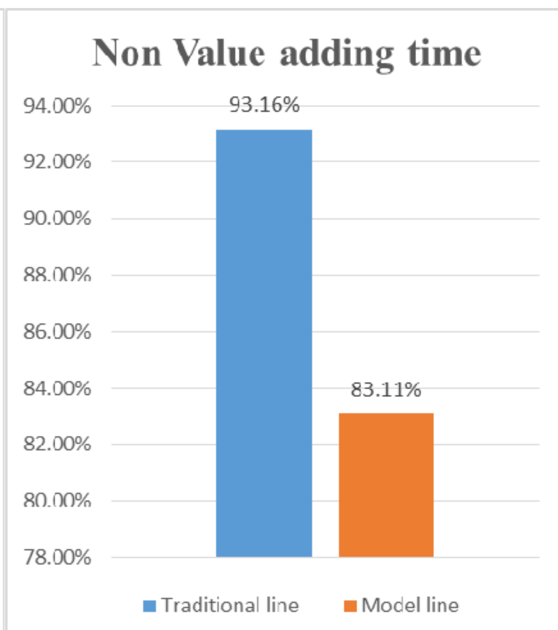


Figure 7.11: Comparison of Non-Value adding

CHAPTER EIGHT

CONCLUSIONS AND RECOMMENDATIONS

8.1 Conclusions

The value stream mapping method (VSM) is a visualization tool oriented to the Toyota Production System. It helps to understand and streamline work process using the tools and technique of lean manufacturing. The goal of VSM is to identify, demonstrate and elimination of waste in the process. Before eliminating waste, we must be able to see it. If we can identify waste, we can target it for elimination. But if we cannot see it, it will remain and add cost. Without VSM problem cannot be identified easily and cannot reduced. VSM can serve as a starting point to help management, engineers, production associates, schedulers, suppliers, and customers, recognize waste and identify its causes. As a result value stream mapping is primarily a communication tool, but is also used as a strategic planning tool and a change management tool.

If we look back of current state assessment. It is found that value adding time is 1.02%, waiting time is 93.16%, line efficiency 57.29% and productivity 2.37 per person per hour. The line is not properly balanced and lots of transportation also need more space. The helper, operator ratio was 1:2.81. Which shows huge opportunities for improvement in those areas.

Before implementation of tools & techniques of lean manufacturing we have to train the people specially supervisor and make them knowledgeable about different types of waste and how to identify waste also how to reduce waste. Also train the operator how to handling the garments & operating or stitching. It has started 10 pieces bundling system from cutting. Then follow up the line regularly and capacity study time to time. Also train about kaizen how small change make their work simple and improve visibility of off-standards and they were introduced to changing for better.

After implementation of team work, different kaizen blitz, process integration, job sharing, multi machine operating and balancing the task also eliminating unnecessary activities, team achieved 58.62% line efficiency, productivity achieved 3 per person per hour, lead time reduction 60.85%, and value adding time increased 153.92% also non value adding time reduction is 10.78%. Besides defects, WIP, transportation, and helper also reduced than previous traditional systems.

8.2 Recommendations

The study was done with a limited scope**.** The future works may include super market pull between cuttings and sewing section also implementation of JIT and Kanban system to keep WIP at minimum level. The future works may also include helper less Zero defect line where each operator will be the quality at the source and creation of standard operating procedure (SOP) for each sections and for Incentive policy also.

REFERENCES

[1] Kapyla, J., Jaaskelainen, A. and Lonnqvist, A., “Identifying future challenges for productivity research: evidence from Finland”, *International Journal of Productivity and Performance Management*, Vol. 59(7), pp. 607-623, 2009.

[2] Heap, J., “Stormy productivity ahead”, *International Journal of Productivity and Performance Management*, Vol. 56(2), pp. 170-177, 2007.

[3] Bicheno, J., “The Lean Toolbox”, PICSIE Books, Buckingham, 2nd Edition, 2000.

[4] Bhote K. R., “The Ultimate Six Sigma: Beyond Quality Excellence to Total Business Excellence”, AMACOM, 2002.

[5] Sun, S., “The Strategic Role of Lean Production in SOE’s Development”, *International Journal of Business & Management*, Vol. 6(2), 2011.

[6] Black J. T. and Hunter S. L., “Lean Manufacturing System and Cell Design”, SME, 2003.

[7] Burkett, M., AMR Report, Enhancing Lean Manufacturing with Software Applications, Jan. 2002.

[8] Bossert J., “Lean and Six Sigma – Synergy Made in Heaven”, Quality Progress, vol. 36(7), pp. 31-32, 2003.

[9] Womack, J. P. and Daniel T. J., “Lean Thinking”, Simon and Schuster, New York, 1996.

[10] Liker, J. K., “The Toyota Way: 14 Management Principles from the World's Greatest Manufacturer”, McGraw-Hill, APA 6th Edition, 2004.

[11] Womack, J., Daniel J., and Daniel R., “The Machine that Changed the World”, Harper Collins, 1990.

[12] Ohno, T., ‘Toyota Production System’, Taylor & Francis, New Edition, 1988.

[13] Schonberger, R. J., “World Class Manufacturing: the lessons of simplicity applied”, New York, The Free Press, 1986.

[14] Womack, J. P. and Jones, D. T., Lean Thinking: Banish Waste and Create Wealth in Your Corporation, New York, Simon & Schuster, 1995.

[15] Hines, P., and Taylor, D., Going Lean, Lean Enterprise Research Center, 2000.

[16] Hasin, A., A., "Quality Control and Management", Bangladesh Business Solutions, 1st Edition, 2007.

[17] Harrison, A., "Just-in-time Manufacturing in Perspective", Prentice Hall, 1992.

[18] Hirano, H., "5S for Operators: 5 Pillars of the Visual Workplace", Taylor & Francis, New Edition, 1998.

[19] Nakajima, S., TPM Development Program: Implementing Total Productive Maintenance, Productivity Press, Cambridge MA, 1989.

[20] Holweg M., "The genealogy of lean production", Science Direct, *Journal of Operations Management,* Vol. 25, pp. 420–437, 2007.

[21] Hines, P. and Rich, N., "The seven value stream mapping tools", *International Journal of Operations & Production Management,* Vol. 17, pp. 46-64, 1997.

[22] Ramesh, V., Prasad, K. V. S., Srinivas, T. R., "Implementation of a Lean Model for Carrying out Value Stream Mapping in a Manufacturing Industry", *Journal of Industrial and Systems Engineering,* Vol. 2(3), pp. 180-196, 2008.

[23] Rother, M. and Shook J., "Learning to see: Value stream mapping to create value and eliminate MUDA", Lean Enterprise Institute Brookline, Massachusetts, USA, 1999.

[24] Millard, R. L., "Value Stream Analysis and Mapping for Product Development", Master's Thesis in Aeronautics and Astronautics, Massachusetts Institute of Technology, 2001.

APPENDICES

Appendix A: Current Data Log Sheet (Cutting)

Activity	Total time (min)	Actual time (min)	Workers	Batch size	Transportation (feet)	Waiting Time
Storing	15	0	0	1430 kg	0	2085
Quality check	25	0	2	142 kg	115	65
Fabric loading spreading	55	0	7	1100 kg	55	14
Lay Translation	3	0	7	1100 kg	5	10
Marker Placing & Attaching	10	0	4	1100 kg	0	30
Cutting	50	42	3	1100 (pcs)	0	30
Numbering	58	0	2	1100 (pcs)	25	98
Bundling	30	0	2	1100 (pcs)	10	56
Cut panel check	45	0	2	1100 (pcs)	15	70
Cut panel replacement	30	0	3	0	25	45
Body pairs	66	0	3	0	55	130
Input Rack (storing)	25	0	0	1100 (pcs)	25	202

Appendix B: Current Data Log Sheet (Sewing)

Activity	C/T (min)	Actual time (min)	Workers	Quantity Output	No of Activities	Batch size (pcs)	Up time	Efficiency (%)	Change Over	Transportation	Defect	Waiting Time
Placket Fusing	0.26	0.13	0	1100	0	30	100%	0.00	0.0	25	0	100
Placket mark for rolling	0.15	0	1	1180	1	25	0	0.59	0.0	2	0	0
Placket Rolling	0.18	0.03	1	1200	2	25	100%	0.62	0.0	2	0	15
Front part mark for placket join	0.2	0	1	1160	1	25	0	0.50	0.0	2	0	0
Placket join	0.22	0.03	1	1120	1	25	100%	0.51	0.0	2	0	28
Placket scissoring	0.30	0	1	1100	2	25	0	0.69	0.0	2	0	7
Nose tack	0.15	0.03	1	1090	2	25	100%	0.34	0.0	2	0	7
Front &Back part match	0.35	0	1	1120	1	25	0	0.82	0.0	2	0	0
Shoulder join	0.23	0.02	1	1120	1	25	100%	0.537	0.0	2	4	30
Label attach	0.22	0.05	1	1110	1	25	100%	0.51	0.0	2	2	4.8
Shoulder T/s	0.18	0.03	1	1115	2	25	100%	0.42	0.0	2	5	9
Collar Cutting	0.25	0.10	1	1120	1	200	100%	0.583	0.0	2	0	8
Collar mark for joining	0.25	0	1	1130	1	200	0	0.589	0.0	2	0	12
Collar join	0.38	0.05	1	580	2	25	100%	0.46	0.0	2	5	13
Collar join	0.43	0.05	1	540	2	25	100%	0.48	0.0	2	5	15
Collar piping	0.20	0.05	1	1140	2	25	100%	0.475	0.0	2	4	15
Collar piping scissoring	0.2	0	1	1140	1	25	0	0.48	0.0	2	0	12
Collar piping T/S	0.37	0.07	1	540	1	25	100%	0.42	0.32	2	12	6
Collar piping T/S	0.37	0.07	1	560	1	25	10%	0.43	0.25	2	12	4

Appendix B: Current Data Log Sheet (Sewing continued)

Activity	C/T (min)	Actual time (min)	Workers	Quantity Output	No of Activities	Batch size (pcs)	Up time	Efficiency (%)	Change Over	Transportation	Defect	Waiting Time
Placket closing	0.25	0.08	1	1080	1	25	100%	0.56	0.0	2	0	8
Placket pattern T/S	0.28	0.07	1	1120	1	25	100%	0.65	0.0	2	0	8
Placket box	0.70	0.07	1	540	2	25	100%	0.79	0.0	2	12	90
Placket box	0.8	0.1	1	520	2	25	100%	0.87	0.0	2	12	55
Sleeve hem	0.3	0.1	1	1100	2	25	100%	0.69	0.0	2	6	8
Sleeve &body Match	0.25	0	1	1110	1	25	0	0.58	0.0	2	0	10
Sleeve join	0.42	0.05	1	580	2	25	100%	0.51	0.0	2	5	7
Sleeve join	0.47	0.05	1	550	2	25	100%	0.54	0.0	2	5	9
Sleeve armhole T/S	0.46	0.08	1	1000	2	25	100%	0.96	3.1	10	5	30
Armhole thread cut	0.26	0	1	1080	1	25	0	0.59	0.0	2	0	5
Bottom hem	0.33	0.12	1	1040	2	25	100%	0.72	0.0	2	10	23
Sleeve opening tuck	0.32	0.10	1	1040	2	25	100%	0.69	0.0	2	0	56
Side seam join	0.59	0.10	1	550	3	25	100%	0.68	0.0	2	3	32
Side seam join	0.55	0.10	1	530	3	25	100%	0.61	0.0	2	3	26
Sleeve outside tack	0.42	0.07	1	1100	2	25	100%	0.96	0.0	2	0	29
Side vent tack	0.28	0.08	1	1070	2	25	100%	0.62	0.0	2	0	17
Side vent joint	0.42	0.08	1	1060	2	25	100%	0.93	0.1	2	4	26
Side vent top stitch	0.46	0.1	1	1060	2	25	100%	1.02	0.0	2	4	62
Barrack	0.23	0.06	1	1070	1	25	100%	0.51	0.15	2	0	8
Button hole	0.32	0.20	1	1060	1	25	100%	0.71	0.0	2	0	13

Appendix B: Current Data Log Sheet (Sewing continued)

Activity	C/T (min)	Actual time (min)	Workers	Quantity Output	No of Activities	Batch size (pcs)	Up time	Efficiency (%)	Change Over	Transportation	Defect	Waiting Time
Button attach mark	0.25	0	1	1060	1	25	0	0.55	0.0	2	0	11
Button attach	0.20	0.10	1	1060	1	25	100%	0.44	0.35	2	0	28
Body turn & thread trimming	0.38	0	1	530	2	25	0	0.42	0.0	2	0	21
Thread cut	0.32	0	1	580	2	25	0	0.39	0.0	2	0	17
Quality check	0.37	0	1	430	1	15	0	0.33	0.0	3	0	12
Quality check	0.4	0	1	410	1	15	0	0.34	0.0	3	0	14
Quality Check	0.27	0	1	450	1	15	0	0.25	0.0	3	0	6
Size label Heat Pressing	0.80	0.42		1040	4	100	100%	1.73	0.0	65	0	27

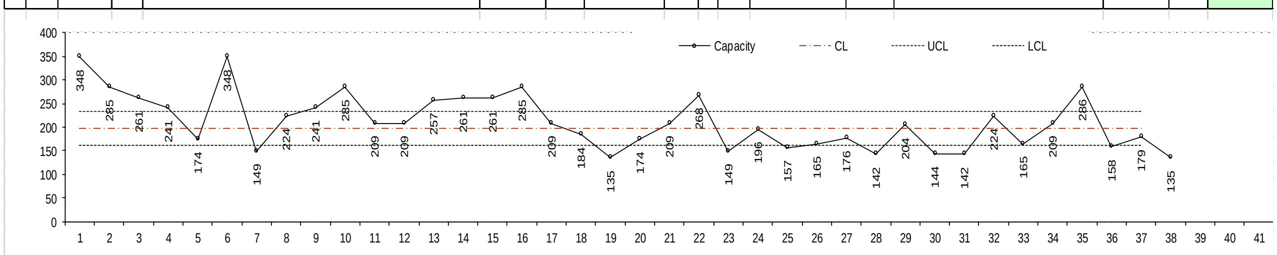
Appendix C: Current Data Log Sheet (Finishing)

Activity	C/T (min)	Actual time (min)	Workers	Quantity Output	No. of Activities	Batch size (pcs)	Efficiency (%)	Change Over	Transportation	Defect	Waiting Time
Ironing (1)	0.88	0.00	1	1100	1	20	2.02	0	65	0	24
Ironing (2)	0.77	0.00	1	1100	1	20	1.76	0	0	0	19
Quality check top side (1)	0.63	0.00	1	350	1	10	0.46	0	2	0	17
Quality check top side (2)	0.53	0.00	1	380	1	10	0.42	0	2	0	11
Quality check (measurement)	0.40	0.00	1	490	1	10	0.41	0	2	0	21
Size wise grouping	0.28	0.00	1	1040	1	15	0.61	0	2	0	9
Hang /price tag attach	0.32	0.00	1	1040	1	5	0.69	0	2	0	8
Folding	0.40	0.00	1	1040	2	6	0.87	0	5	0	13
Poly	0.30	0.00	1	1040	1	6	0.65	0	5	0	6
Barcode attach on poly	0.18	0.00	1	1040	1	3	0.39	0	10	0	4
Metal pass	0.07	0.04	1	1200	1	120	0.18	0	0	0	0
Cartooning	0.48	0.00	2	1200	1	10	1.20	0	0	0	40

Appendix D: Current state line graph

Team : 31	Present Graph Date: 1-Aug-15	1st	Performance: 77%	Total Operator: 31	
Style : 2043	Previous Graph Date:	Prod. Start Date: 25-Jul-15	Balance (%): 68%	Total Asst. Operator: 11	
Buyer : M&S	Lowest Capacity/Hr: 135 Pcs	SMV: 8.50	Efficiency: 45%	Total: 42	
Item : POLO	Capacity Achieved: 130 Pcs	TACCT: 11.10	Prod. Gap: 4%	Study By: Mahabub	

Sl.	Opt n	Name	ID	Operation		Time	Capacity		Sl.	Opt n	Name	ID	Operation		Time	Capacity
1	1			Placket mark for rolling	SNL	9	**348**		29	25			Bottom hem	FL	20	**157**
2	2			Placket Rolling	SNL	11	**285**		30	26			Sleeve Opening tack	SNL	19	**165**
3	3			Front part mark for placket join	M	12	**261**		31	27			Side seam join	OL	35	**89**
4	4			Placket join	SNL	13	**241**		32	27			Side seam join	OL	36	**87**
5	5			Placket scissoring	M	18	**174**		33	28			Sleeve out side tack	SNL	22	**142**
6	6			Nose tack	SNL	9	**348**		34	29			Side vent tack	SNL	17	**184**
7	7			Front &Back part match	M	21	**149**		35	30			Side vent joint	SNL	25	**125**
8	8			Shoulder join	OL	14	**224**		36	31			Side vent top stitch	SNL	22	**142**
9	9			Lable attatch	SNL	13	**241**		37	32			Bartack	BKT	14	**224**
10	10			Shoulder T/s	FL	11	**285**		38	33			Button hole	HOLE	19	**165**
11	11			Collar Cutting	V-TRIM	15	**209**		39	34			Button attatch mark	M	15	**209**
12	12			Collar mark for joining	M	15	**209**		40	35			Button attatch	BTN	12	**261**
13	13			Collar join	SNL	23	**136**		41	36			Body turn & thread trimming	M	23	**136**
14	13			Collar join	SNL	26	**120**		42	37			Thread cut	M	19	**165**
15	14			Collar piping	SNL	12	**261**									
16	15			Collar piping scissering	M	12	**261**									
17	16			Collar piping T/S	SNL	22	**142**									
18	16			Collar piping T/S	SNL	22	**142**									
19	17			Placket closeing	SNL	15	**209**									
20	18			Placket pattern T/S	SNL	17	**184**									
21	19			Placket box	SNL	45	**70**									
22	19			Placket box	SNL	48	**65**									
23	20			Sleeve hem	FL	18	**174**									
24	21			Sleeve &body Match	M	15	**209**									
25	22			Sleeve join	OL	22	**142**									
26	22			Sleeve join	OL	25	**125**									
27	23			Sleeve armmhole T/S	FL	21	**149**									
28	24			Armmhole thread cut	M	16	**196**									



Appendix E: Skill Matrix Process name

Category	A(Very Good)		B(Good)		C(Medium)	
M/C	Process	Production/ Hr	Process	Production/ Hr	Process	Production /Hr
SNL	Zipper joint	60	Patch label join	100	Back neck piping	150
	Zipper top	65	Placket 1/16 top	150	V-make	140
	Collar band joint	70	Placket kacha	140	Flag label joint	160
	Placket box	80	Bone joint with rolling	70	Sleeve 1/4 tack	140
	Placket box(X)	60	Waist belt tack	70	Sleeve opening tack	140
	Side vent join	80	Pattern top	140	Placket Rolling	160
	Side vent top	80	Moon joint	110		
	V-neck tack with body	130	Placket joint	115		
	Back neck tape top	140	Placket joint(Stripe)	80		
	Collar joint	130	Back Neck tape joint	120		
	Collar top with label	130	Bone top	80		
	Collar & Zipper mouth closing	50	Pocket joint	80		
	Bone tack	60	Pocket joint(Diamond)	60		
OL	Bottom joint	80	Hood join	80	Back rise	160
	Cuff joint	80	Sleeve join	100	Front rise	160
	Mora sleeve joint	65	Side seam (Solid)	90	Moon overlock	180
	Round Neck joint (without rollar)	160	In seam	100	Shoulder join	160
	V-Neck joint	140				
	Side seam (Stripe)	55				
	Blind sleeve Hem	70				
	Waist belt join	80				
FL	Body hem (with thread cut)	160	Sleeve hem (open)	160	Shoulder top	160
	Slv hem(Round/ Churi hem)	120	Arm hole piping	140	Front neck top	170
	Side top	80	Cuff top	120	Moon top	170
	Neck binding	150	Front V-neck top	140	Back Neck piping	180
	Leg hem	80	Hood hem	80		
	Arm hole top	120				
	Waist belt top	120				
SPECIAL	Snap button (3)	60	Double needle CS	120		
	Hole stitch (3)	120	Bartack (2)	160		
	Zig zag	100	Button stitch (3)	120		

Appendix F: Skill Matrix Inventory

Summary	Plain m/c	Over lock m/c	Flat lock m/c	Others	Total
A	11	3	3	2	19
B	7	8	6	1	22
C	2	4	5	1	12

No	Operator Name	ID No	Process Name	Plain m/c	O/L m/c	F/L m/c	Others
1	Shajada	W-1811471	B/k part label attach & Thread cut	B		C	
2	Nurjahan	W-4812364	Placket rolling & T/C	B	C		C
3	Parul	3121649	Placket join	A		B	
4	Khadeja	320499	Nose tack & scissoring	A			
5	Mahabuba	3115500	Sleeve & bottom hem		B	A	
6	Toli	3112084	Sleeve & bottom hem		C	A	
7	Jorina	316347	Shoulder join &Thread cut		B	B	
8	Jismin	3121460	Shoulder T/S &Thread cut	B		B	
9	Nazmul	3120678	Collar join	A		C	
10	Sharmin	3118663	Collar piping & Scissoring	A		B	
11	Shalma	W-4811474	Collar piping T/S & T/C	B	B		
12	Halima	3121624	Collar join & Collar piping T/S	A		C	
13	Kalpona	3119539	Placket closing & T/C	B	B		
14	Jahanara	3119442	Placket closing & T/C	A	B		
15	Moni	3113645	Placket box T /S	A		B	
16	Monora	3113742	Placket box T /S	A		B	
17	Moksuda	3124190	Sleeve join & T/S	B	A		
18	Laily	3121418	Sleeve arm hole T/S & TC		B	A	
19	Shorifa	319611	Side seam join & T/C	C	A		
20	Kuddus	3114577	Side seam join & Sleeve join	C	A		
21	Shobuj	3121886	Sleeve inside & Outside tuck & TC	A	C	C	
22	Sharmin	3115402	Sleeve inside & Outside tuck & TC	B	C		
23	Lipe	3116266	Side vent tuck & T/S & TC	A	B	C	
24	Kohenur	W-5111633	Side vent tuck & T/S & TC	A	B		
25	Shano	W-4815031	Bar tack & Button				B
26	Rima	3116127	Button hole & button attach Mark				A
27	Ranoka	3115952	Button attach				A

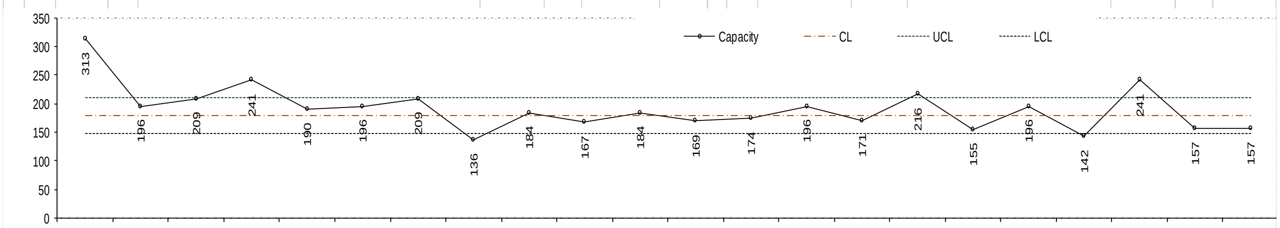
Appendix G: Task Comparison of Helper Replacement

Previous layout (Polo shirt)			*Present layout (Polo shirt)*		
Sl No	**Helper using area**	**Why use helper**	**Sl No**	**Implementation plan**	**How**
1	Placket mark	Placket rolling & placket attach with front part	1	Reduce helper	By using laser light in marking area
2	Front body mark	Front body mark for attach placket in middle position	2	Reduce helper	By using cu mark in body
3	Placket scissoring	For divided the placket in two part & nose tuck	3	Reduce helper	Replace by nose tuck Operator
4	Front & Back part match	For maintain numbering serial front & back part	4	Reduce helper	By maintain properly bundle serial
5	Collar mark	For collar join	5	Reduce helper	By mark from cutting band knife m/c
6	Piping scissoring	For piping T/S	6	Reduce helper	Helper job share by operator
7	Sleeve & body match	For maintain serial body & sleeve	7	Reduce helper	By maintain properly bundle serial
8	Armhole thread cutting	Helping work for armhole T/S	8	Reduce helper	Helper job share by operator
9	Button attach mark	For positioning button attach	9	Reduce helper	Replace by bar tack operator & BH operator
10	Thread trimming	Reduce extra thread from body	10	Not change helper	Developed new thread cutting table for TC
11	Trimming	Reduce extra thread from body	11	Not change helper	Developed new thread cutting table for TC

Appendix H: Future state Line Graph

Team :	31	Present Graph Date:	1-Aug-15			1st	Performance:	101%	Total Operator:	27
Style :	2043	Previous Graph Date:			Prod. Start Date:	25-Jul-15	Balance (%):	76%	Total Asst. Operator:	2
Buyer :	M&S	Lowest Capacity/Hr:	136	Pcs	SMV:	8.50	Efficiency:	66%	Total:	29
Item :	POLO	Capacity Achieved:	125	Pcs	TACCT:	8.43	Prod. Gap:	8%	Study By:	Mahabub

SL	Optn	Name	ID	Operation		Time	Capacity		SL	Optn	Name	ID	Operation		Time	Capacity
1	1			Bk part Label attach & Tread Cut	SNL	10	**313**		31	22			Thread cut using developed t	M	20	**157**
2	2			Placket Rolling & TC	SNL	16	**196**									
3	3			Placket joint	SNL	15	**209**									
4	4			Nose tuck & scissoring	SNL	13	**241**									
5	5			Sleeve & bottom hem	FL	33	**95**									
6	5			Sleeve & bottom hem	FL	33	**95**									
7	6			Shouldr joint & Thread cutt	OL	16	**196**									
9	7			Shoulder T/S & Thread cut	FL	15	**209**									
10	8			Collar joint	SNL	23	**136**									
12	9			Collar piping & scissoring	SNL	17	**184**									
13	10			Collar piping T/S & TC	SNL	27	**116**									
14	10			Collar joint & collar piping T/S	V-TRIM	61	**51**									
15	11			Placket Closing & Top stitch	SNL	34	**92**									
16	11			Placket Closing & Top stitch	SNL	34	**92**									
17	12			Placket box & TC	SNL	37	**85**									
18	12			Placket box & TC	SNL	37	**85**									
19	13			Sleeve joint & TC	OL	18	**174**									
20	14			Sleeve armmhole T/S & thread cut	FL	16	**196**									
21	15			Side seam joint & TC	OL	31	**101**									
22	15			Side seam joint & Sleeve joint	OL	45	**70**									
23	16			Sleeve inside & Outside tuck & TC	SNL	28	**112**									
24	16			Sleeve inside & outside tuck & TC	SNL	30	**104**									
25	17			Side vent tuck & T/S & TC	SNL	42	**75**									
26	17			Side vent tuck & T/S & TC	SNL	39	**80**									
27	18			Bartack & Button	BTK	16	**196**									
28	19			Button hole & button attach mark	HOLE	22	**142**									
29	20			Button attach	BTN	13	**241**									
30	21			Body turn & thread trimming	M	20	**157**									
						.										



Appendix I: Future Data Log Sheet (Cutting)

Activity	Total time (min)	Actual time (min)	Workers	Batch size	Transportation (feet)	Waiting Time
Storing Quality Check	15	0	0	1430kg	0	780
Fabric Loading & Spreading	55	0	5	1100	30	12
Marker Placing & Attachment	10	0	4	1100	0	5
Cutting	50	42	3	1100	0	25
Cut panel check& Bundling	45	0	2	1100	15	70
Cut panel replacement	30	0	3	10	25	24
Placket Fusing	0.26	0.13	0	10	25	15
Body pairs	66	0	3	10	40	15
Input Rack(Storing)	20	0	0	1100 pcs	25	180

Appendix J: Future Data Log Sheet (Sewing)

Activity	C/T (min)	Actual time (min)	Workers	Quantity Output	No of Activities	Batch size (pcs)	Up time	Efficiency (%)	Change Over	Transportation	Defect	Waiting Time
Bake part Label attach & Tread Cut	0.22	0.05	1	1110	2	10	100%	0.51	0.00	2	1	0
Placket Rolling & TC	0.27	0.03	1	1100	2	10	100%	0.61	0.00	2	0	0
Placket joint	0.25	0.03	1	1110	1	10	100%	0.58	0.00	2	1	5
Nose tuck & scissoring	0.25	0.02	1	1115	2	10	100%	0.58	0.00	2	1	4
Sleeve & bottom hem	0.55	0.12	1	540	2	10	100%	0.62	0.00	2	2	8
Sleeve & bottom hem	0.61	0.12	1	510	2	10	100%	0.65	0.00	2	1	6
Should joint & Thread cut	0.28	0.02	1	1050	2	10	100%	0.62	0.00	2	0	10
Shoulder T/S & Thread cut	0.29	0.03	1	1060	2	10	100%	0.63	0.00	2	2	9
Collar joint	0.40	0.05	1	800	1	10	100%	0.67	0.00	2	2	6
Collar piping & scissoring	0.33	0.05	1	1070	2	10	100%	0.72	0.00	2	0	8
Collar piping T/S & TC	0.45	0.07	1	820	2	10	100%	0.77	0.32	2	1	6
Collar joint & collar piping T/S	1.01	0.12	1	380	2	10	100%	0.80	0.32	2	0	9
Placket Closing & Top stitch	0.57	0.10	1	520	2	10	100%	0.61	0.00	2	0	8
Placket Closing & Top stitch	0.49	0.10	1	580	2	10	100%	0.59	0.00	2	0	7

Appendix J: Future Data Log Sheet (Sewing continued)

Activity	C/T (min)	Actual time (min)	Workers	Quantity Output	No of Activities	Batch size (pcs)	Up time	Efficiency (%)	Change Over	Transportation	Defect	Waiting Time
Placket box & TC	0.62	0.07	1	570	2	10	100%	0.73	0.00	2	2	15
Placket box & TC	0.70	0.07	1	510	2	10	100%	0.74	0.00	2	2	12
Sleeve joint & TC	0.30	0.05	1	810	2	10	100%	0.51	0.00	2	0	7
Sleeve armhole T/S & thread cut	0.27	0.07	1	1100	2	10	100%	0.61	3.1	2	2	8
Side seam joint & TC	0.75	0.07	1	620	2	10	100%	0.97	0.00	2	1	10
Side seam joint & Sleeve joint	0.75	0.12	1	380	2	10	100%	0.59	0.00	2	0	10
Sleeve inside & Outside tuck & TC	0.47	0.08	1	580	3	10	100%	0.56	0.00	2	0	5
Sleeve inside & outside tuck & TC	0.50	0.07	1	540	3	10	100%	0.56	0.1	2	0	15
Side vent tuck & T/S & TC	0.70	0.10	1	520	3	10	100%	0.76	0.1	2	0	12
Side vent tuck & T/S & TC	0.65	0.10	1	570	3	10	100%	0.77	0.1	2	1	8
bar tack & Button	0.48	0.07	1	960	2	10	100%	0.97	0.00	2	0	10
Button hole & button attach mark	0.42	0.20	1	1010	1	10	100%	0.88	0.00	2	1	18
Button attach	0.22	0.10	1	1000	1	10	100%	0.45	0.35	2	0	20
Body turn & thread trimming	0.38	0	1	490	2	10	0	0.39	0.00	1	0	15
Thread cut using developed thread cutting table	0.32	0	1	520	2	10	0	0.35	0.00	1	0	22
Size label Heat Pressing	0.80	0.42	0	960	4	10	100%	1.60	0.00	65	0	45

Appendix K: Future Data Log Sheet (Finishing)

Activity	C/T (min)	Actual time (min)	Workers	Quantity Output	No. of Activities	Batch size (pcs)	Efficiency (%)	Change Over	Transportation	Defect	Waiting Time
Ironing	0.88	0	1	450	1	10	0.83	0	2	0	10
Ironing	0.77	0	1	530	1	10	0.85	0	2	0	15
Quality Check Top side & Measurement	0.63	0	1	400	1	10	0.53	0	2	0	18
Quality Check Top side & Measurement	0.53	0	1	420	1	10	0.46	0	2	0	11
Quality Check Top side & Measurement	0.4	0	1	430	1	10	0.36	0	2	0	10
Hang/Price tag and barcode attach on poly	0.45	0	1	970	2	5	0.91	0	2	0	15
Folding & Poly	0.52	0	1	520	2	5	0.56	0	3	0	9
Folding & Poly	0.57	0	1	450	2	5	0.43	0	30	0	25
Metal Pass	0.07	0.04	1	960	1	120	0.14	0	8	0	0
Cartooning	0.48	0	2	1000	1	10	1.00	0	0	0	10

Appendix L: Automation of Bundling System

P. DT. 14-Sep-2015	**Buyer: ESPRIT**	**Bundle No: 1**
BACK	Gmt: 1 - 4	**Size: S**
Style: 995EE2J901		**Qty: 4**
Clr: MEDIUM GREY(E070)		**Cut No: 61**
A.CutID: 12776	**Lot No: 8221/ R - 1**	Ordr No: 0

P. DT. 14-Sep-2015	**Buyer: ESPRIT**	**Bundle No: 2**
BACK	Gmt: 5 - 8	**Size: S**
Style: 995EE2J901		**Qty: 4**
Clr: MEDIUM GREY(E070)		**Cut No: 61**
A.CutID: 12776	**Lot No: 8221/ R - 2**	Ordr No: 0

P. DT. 14-Sep-2015	**Buyer: ESPRIT**	**Bundle No: 3**
BACK	Gmt: 9 - 16	**Size: S**
Style: 995EE2J901		**Qty: 8**
Clr: MEDIUM GREY(E070)		**Cut No: 61**
A.CutID: 12776	**Lot No: 8221/ R - 3**	Ordr No: 0

P. DT. 14-Sep-2015	**Buyer: ESPRIT**	**Bundle No: 4**
BACK	Gmt: 17 - 20	**Size: S**
Style: 995EE2J901		**Qty: 4**
Clr: MEDIUM GREY(E070)		**Cut No: 61**
A.CutID: 12776	**Lot No: 8221/ R - 4**	Ordr No: 0

P. DT. 14-Sep-2015	**Buyer: ESPRIT**	**Bundle No: 5**
BACK	Gmt: 21 - 27	**Size: S**
Style: 995EE2J901		**Qty: 7**
Clr: MEDIUM GREY(E070)		**Cut No: 61**
A.CutID: 12776	**Lot No: 8106/ R - 1**	Ordr No: 0

P. DT. 14-Sep-2015	**Buyer: ESPRIT**	**Bundle No: 6**
BACK	Gmt: 28 - 35	**Size: S**
Style: 995EE2J901		**Qty: 8**
Clr: MEDIUM GREY(E070)		**Cut No: 61**
A.CutID: 12776	**Lot No: 8106/ R - 2**	Ordr No: 0

P. DT. 14-Sep-2015	**Buyer: ESPRIT**	**Bundle No: 7**
BACK	Gmt: 1 - 4	**Size: M**
Style: 995EE2J901		**Qty: 4**
Clr: MEDIUM GREY(E070)		**Cut No: 61**
A.CutID: 12776	**Lot No: 8221/ R - 1**	Ordr No: 0

P. DT. 14-Sep-2015	**Buyer: ESPRIT**	**Bundle No: 8**
BACK	Gmt: 5 - 8	**Size: M**
Style: 995EE2J901		**Qty: 4**
Clr: MEDIUM GREY(E070)		**Cut No: 61**
A.CutID: 12776	**Lot No: 8221/ R - 2**	Ordr No: 0

P. DT. 14-Sep-2015	**Buyer: ESPRIT**	**Bundle No: 9**
BACK	Gmt: 9 - 16	**Size: M**
Style: 995EE2J901		**Qty: 8**
Clr: MEDIUM GREY(E070)		**Cut No: 61**
A.CutID: 12776	**Lot No: 8221/ R - 3**	Ordr No: 0

P. DT. 14-Sep-2015	**Buyer: ESPRIT**	**Bundle No: 10**
BACK	Gmt: 17 - 20	**Size: M**
Style: 995EE2J901		**Qty: 4**
Clr: MEDIUM GREY(E070)		**Cut No: 61**
A.CutID: 12776	**Lot No: 8221/ R - 4**	Ordr No: 0

P. DT. 14-Sep-2015	**Buyer: ESPRIT**	**Bundle No: 11**
BACK	Gmt: 21 - 27	**Size: M**
Style: 995EE2J901		**Qty: 7**
Clr: MEDIUM GREY(E070)		**Cut No: 61**
A.CutID: 12776	**Lot No: 8106/ R - 1**	Ordr No: 0

Solid Part

P. DT. 14-Sep-2015	**Buyer: ESPRIT**	**Bundle No: 12**
BACK	Gmt: 28 - 35	**Size: M**
Style: 995EE2J901		**Qty: 8**
Clr: MEDIUM GREY(E070)		**Cut No: 61**
A.CutID: 12776	**Lot No: 8106/ R - 2**	Ordr No: 0

P. DT. 14-Sep-2015	**Buyer: ESPRIT**	**Bundle No: 13**
BACK	Gmt: 1 - 4	**Size: L-A**
Style: 995EE2J901		**Qty: 4**
Clr: MEDIUM GREY(E070)		**Cut No: 61**
A.CutID: 12776	**Lot No: 8221/ R - 1**	Ordr No: 0

P. DT. 14-Sep-2015	**Buyer: ESPRIT**	**Bundle No: 14**
BACK	Gmt: 5 - 8	**Size: L-A**
Style: 995EE2J901		**Qty: 4**
Clr: MEDIUM GREY(E070)		**Cut No: 61**
A.CutID: 12776	**Lot No: 8221/ R - 2**	Ordr No: 0

P. DT. 14-Sep-2015	**Buyer: ESPRIT**	**Bundle No: 15**
BACK	Gmt: 9 - 16	**Size: L-A**
Style: 995EE2J901		**Qty: 8**
Clr: MEDIUM GREY(E070)		**Cut No: 61**
A.CutID: 12776	**Lot No: 8221/ R - 3**	Ordr No: 0

P. DT. 14-Sep-2015	**Buyer: ESPRIT**	**Bundle No: 16**
BACK	Gmt: 17 - 20	**Size: L-A**
Style: 995EE2J901		**Qty: 4**
Clr: MEDIUM GREY(E070)		**Cut No: 61**
A.CutID: 12776	**Lot No: 8221/ R - 4**	Ordr No: 0

P. DT. 14-Sep-2015	**Buyer: ESPRIT**	**Bundle No: 17**
BACK	Gmt: 21 - 27	**Size: L-A**
Style: 995EE2J901		**Qty: 7**
Clr: MEDIUM GREY(E070)		**Cut No: 61**
A.CutID: 12776	**Lot No: 8106/ R - 1**	Ordr No: 0

P. DT. 14-Sep-2015	**Buyer: ESPRIT**	**Bundle No: 18**
BACK	Gmt: 28 - 35	**Size: L-A**
Style: 995EE2J901		**Qty: 8**
Clr: MEDIUM GREY(E070)		**Cut No: 61**
A.CutID: 12776	**Lot No: 8106/ R - 2**	Ordr No: 0

P. DT. 14-Sep-2015	**Buyer: ESPRIT**	**Bundle No: 19**
BACK	Gmt: 36 - 39	**Size: L-B**
Style: 995EE2J901		**Qty: 4**
Clr: MEDIUM GREY(E070)		**Cut No: 61**
A.CutID: 12776	**Lot No: 8221/ R - 1**	Ordr No: 0

P. DT. 14-Sep-2015	**Buyer: ESPRIT**	**Bundle No: 20**
BACK	Gmt: 40 - 43	**Size: L-B**
Style: 995EE2J901		**Qty: 4**
Clr: MEDIUM GREY(E070)		**Cut No: 61**
A.CutID: 12776	**Lot No: 8221/ R - 2**	Ordr No: 0

P. DT. 14-Sep-2015	**Buyer: ESPRIT**	**Bundle No: 21**
BACK	Gmt: 44 - 51	**Size: L-B**
Style: 995EE2J901		**Qty: 8**
Clr: MEDIUM GREY(E070)		**Cut No: 61**
A.CutID: 12776	**Lot No: 8221/ R - 3**	Ordr No: 0

P. DT. 14-Sep-2015	**Buyer: ESPRIT**	**Bundle No: 22**
BACK	Gmt: 52 - 55	**Size: L-B**
Style: 995EE2J901		**Qty: 4**
Clr: MEDIUM GREY(E070)		**Cut No: 61**
A.CutID: 12776	**Lot No: 8221/ R - 4**	Ordr No: 0

Page 1/7