International Journal of
Supply Chain Management
(IJSCM)

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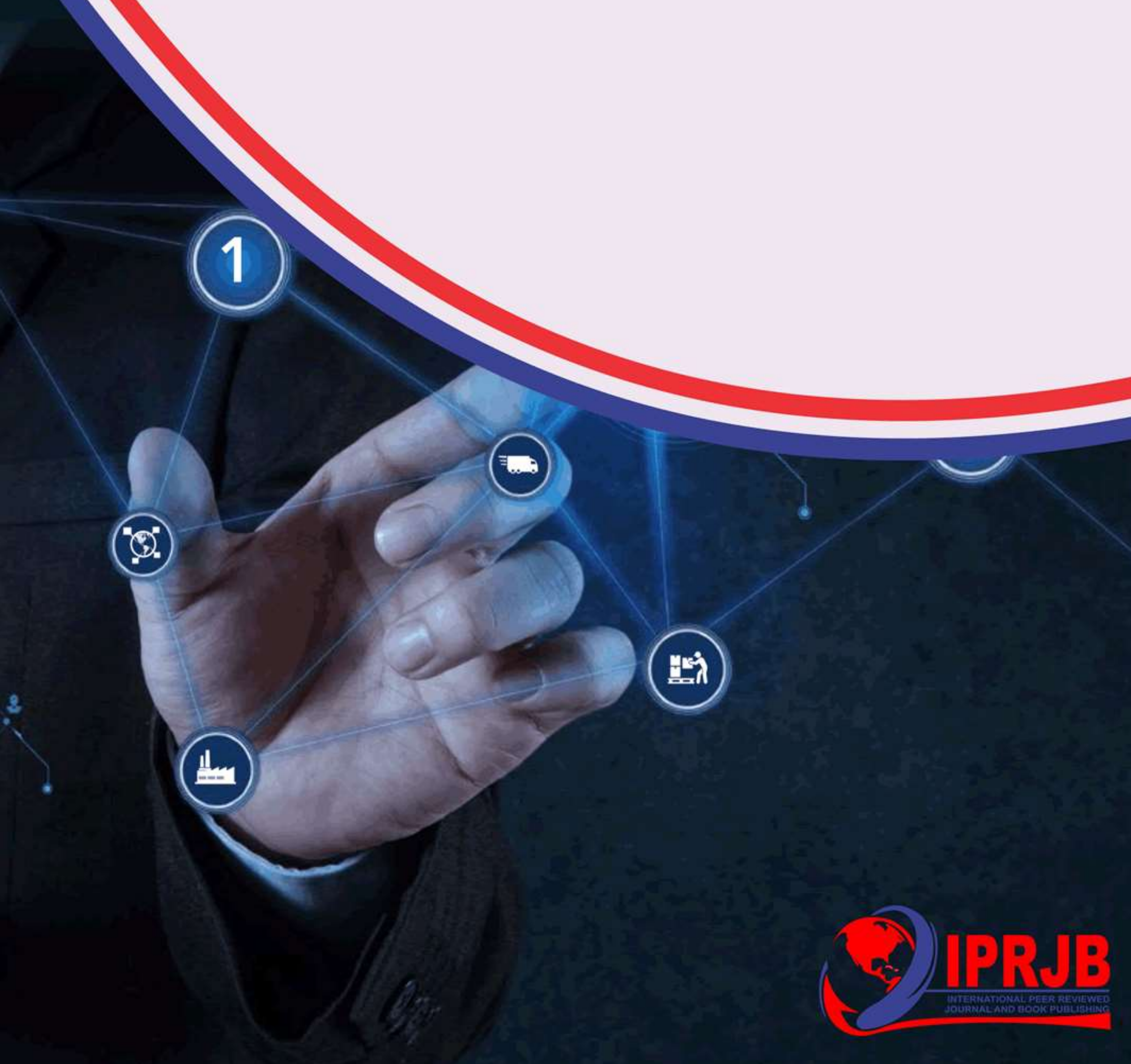

International Journal of Supply Chain Management
ISSN 2518-4709 (Online)
Vol.9, Issue 2, No.3, pp 37 - 61, 2024

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Reduction of Lean Wastes by Using Value Stream Mapping: A Case Study of Textile Company in Pakistan

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Article History

Received 23rd February 2024

Received in Revised Form 1st March 2024

Accepted 9th March 2024

How to cite in APA format:

Kumar, A., Kumar, R., & Gul, A. (2024). Reduction of Lean Wastes by Using Value Stream Mapping: A Case Study of Textile Company in Pakistan. *International Journal of Supply Chain Management*, *9*(2), 37–61. https://doi.org/10.47604/ijscm.2399

Abstract

Purpose: Lean manufacturing, originating from the Toyota Production System (TPS), aims to reduce waste and optimize resources. Developed countries must adopt Lean practices for performance improvements while developing countries often use just-in-case approaches. Value Stream Mapping (VSM) is a crucial tool for diagnosing, implementing, and maintaining Lean Manufacturing, helping identify improvement opportunities and eliminating waste. The research at the company aims to eliminate Lean wastes and line unbalancing issues to improve lead time and the value-added ratio (VAR), enhancing production efficiency. The research aligns with Sustainable Development Goal 12 (Responsible Production & Consumption) by focusing on waste reduction.

Methodology: The research uses time study, Edaw max, and Visio software to analyze tasks, create VSMs of current and future states, and control charts to examine data variations over time. Data collection involves cycle time, batch size, packet size, and the number of workers required for each activity.

Findings: The research objectives include studying the existing scenario of production units via VSM, identifying, and eliminating Lean wastes, and comparing proposed and existing scenarios for improvement opportunities. The literature review highlights the importance of Lean manufacturing in eliminating unnecessary processes, reducing lead time, and fostering positive stakeholder relationships.

Unique Contribution to Theory, Practice and Policy: This study suggests the better way to reduce the lean wastages and balance the line by using VSM technique. The future state VSM is created to conceptualize potential improvements and gather feedback, focusing on reducing non-value-adding tasks, work-in-process inventory, workforce, and overall process time.

Keywords: *Lean Manufacturing, Lean Wastes, Value Stream Mapping, Textile Industry*, *Stitching Department, Time Study*

INTRODUCTION

Toyota Production System (TPS) introduced lean manufacturing; a concept adopted by developed countries for performance improvements. However, developing countries still use just-in-case approaches, leading to poor performance. Implementation of lean manufacturing, piloted by Toyota in the 1970s, reduced waste and inventory[1]. Lean manufacturing reduces waste by focusing on value-added and non-value-added activities. Tools like value stream mapping reduce lead time, cycle, and takt time, and improve production. Hybrid production control strategies enhance results and reduce inventory[2]. Lean manufacturing (LM) is a crucial evolution in various sectors, involving all organizational levels. VSM, a technique for diagnosing, implementing, and maintaining LM, helps identify improvement opportunities and waste elimination, providing a standardized approach[3].

Value Stream Mapping (VSM) is a qualitative process that maps the manufacturing plant state, identifies waste, and eliminates it, aiding small-scale industries in understanding Lean Manufacturing's power by reducing cycle times, lead times, and inventory[4]. It is a lean manufacturing method that enhances inventory and information flow, identifies waste, and implements lean principles. It outlines customer requirements, process steps, metrics, inventory, supplier material flows, total lead time, and Takt time [5]. Value stream mapping is a lean tool for analyzing a company's current scenario and information flow, identifying problems and opportunities for improvement. It covers all processes from customer orders to product delivery, ensuring efficient data collection and planning[6].

Value stream mapping is a tool for enterprise improvement that visualizes production processes, including material and information flow, and documents relationships between manufacturing processes and management controls[7]. It is a crucial tool in lean manufacturing (LM) that helps identify waste in value streams and find appropriate routes for its removal. It involves visually mapping the flow of information and material, including resources and communications. LM focuses on delivering high-quality products on time and at the lowest cost, eliminating waste by all members of the organization. VSM has been successfully implemented in small and medium enterprises (SMEs) to improve their competitiveness and produce high-quality products[8].

Organizations are increasingly competitive due to increased customer demand, leading to a need for improved production processes [9]. To reduce waste, value stream mapping (VSM) tools are used to analyze material and information flow, identify losses, and reduce the time between order placement and product delivery. VSM can be analyzed statically or through simulation, adding time dynamics and aiding decision-making regarding production process changes[10].

Problem Statement

Currently, textile company is facing an increased Lead time issue related to the supply, production & transportation. It is observed in the literature that increased lead time issues occurring in production may also lead the poor production efficiency which is also caused by lean wastes & line unbalancing issues. Hence the focus of this study is to eliminate lean wastes & line unbalancing issues of production to improve the lead time and value-added ratio (VAR) for enhancing the efficiency of production.

Research Aims

Considering the above problem statement & following the sustainable development goal. The aim to improve the flow of production lines through the elimination of lean waste.

Sustainable Goal

The SDG followed in this research is SDG12 which is **Responsible Production & Consumption which means the** preservation of resources during production and Consumption through waste reduction.

Research Objectives

To study the existing scenario of production units via VSM. To identify & eliminate Lean Wastes of production units. To compare proposed & existing scenarios via VSM for improvement opportunities.

LITERATURE REVIEW

Lean manufacturing eliminates unnecessary processes, reducing lead time and waste. It's a method that fosters positive relationships between customers, producers, and suppliers. Despite initial challenges, successful implementation can lead to increased customer satisfaction and reduced inventory [8]. Lean methodology is a flexible solution for various production or service creation industries, with five basic tools for implementation. It focuses on inventory reduction, efficient manpower utilization, order lead time improvement, customer satisfaction, and statistical process control. Value stream mapping (VSM) maps an organization's entire process, identifying value-adding and non-value-adding processes[1].

The Lean Production System (LPS) is a systematic approach to identifying and eliminating wastages in manufacturing processes to improve customer satisfaction and reduce costs. It consists of tools like VSM, 5S, SMED, and standardized work, which focus on specific aspects of a manufacturing process to eliminate waste and improve quality while reducing production time and cost. VSM has been applied in various industries, such as bread manufacturing in Zimbabwe, semi-automated factories in Texas, and crankshaft manufacturing in India[11].

Toyota pioneered value stream mapping (VSM) techniques to implement Lean concepts, minimizing waste and ensuring a continuous flow of products and information throughout a value stream through visualization[12]. In today's global market, companies are implementing lean manufacturing strategies like the Toyota Production System (TPS) to improve efficiency and competitiveness. Lean thinking involves defining value from customer perspectives, determining value streams, achieving flow, scheduling production, and seeking perfection through continuous improvement. Lean accounting and thinking provide reliable decision-making information[13].

Value stream mapping (VSM) is a visual tool that captures the input/output of various processes, based on five lean management principles: defining value, developing value streams, eliminating wastes, and allowing uninterrupted flow. Toyota's average value-added time is over 50%, and wastes in the Product Development Process should be identified and eliminated[14].

Lean manufacturing is a strategy adopted by major manufacturing plants in Asia, particularly in Malaysia, to remain competitive in the global market. It focuses on cost reduction by eliminating non-value-adding activities and waste from each step in the production chain. Lean manufacturing tools and techniques, such as just-in-time (JIT), cellular manufacturing, total productive maintenance, and production smoothing, have been extensively used since the birth of the Toyota Production System. The Toyota Production System (TPS) is a systematic approach to identify and eliminate waste activities through continuous improvement[15].

Lean management, developed by Toyota in the 1940s, focuses on reducing non-value-added activities like waste. Value Stream Mapping (VSM) is a crucial tool for lean thinkers, aiding in waste elimination. Lean has contributed to organizational objectives like profitability, efficiency, and customer satisfaction. However, the integration of lean with green initiatives is a recent research stream, aiming to improve environmental performance[16]. Toyota's executive Taiichi Ohno developed TPS, focusing on quality and diversity in the automotive industry. Lean manufacturing aims to maximize value by eliminating production waste. Ohno identified seven common wastes, which negatively impact production costs and productivity. Lean management methods have been successful in various industries[17].

The integration of Lean and Green principles in industries has led to the development of tools like Green VSM and Sustainable VSM. These focus on energy and cost savings, while green manufacturing includes environmentally friendly materials and processes. IoT technology offers a digital twin enabled VSM solution[18].

The use of Value Stream Mapping (VSM) in Zimbabwe's bread manufacturing industry, highlights its effectiveness in reducing waste. The case study demonstrates that the VSM tool reduced defects by 20%, unnecessary inventory by 18%, and motion by 37%. The study emphasizes the importance of waste relationship ranking and management commitment to waste reduction, highlighting the potential of VSM in enhancing manufacturing efficiency[19].

A value stream mapping study in Fars province, Iran, reveals significant data gaps in wheat and bread loss and waste. The study identifies hotspots in farms, food service, and households, highlighting the need for transparency and further research. The study suggests that researchers can use this holistic approach to investigate loss and waste in other food items across different geographical contexts, enhancing the scope of lifecycle assessment and circular economy studies[20].

The Value Stream Mapping (VSM) method was used in Southern Africa's iron and steel industry to identify and evaluate industrial waste. The method involved collecting and verifying waste generation data, mapping waste generation and fractions, and compiling state maps. The first year saw a 28% reduction in waste and a 45% reduction in waste removal costs, exceeding the initial 5% reduction target[21].

One project demonstrates the importance of Value stream mapping (VSM) in enhancing productivity and business strategy in the power generation industry. By identifying and redesigning a layout, a new layout was developed, demonstrating the practicality of VSM in generating effective genset manufacturing assembly[22].

VSM is a lean manufacturing technique that helps organizations identify and eliminate waste in their processes. It bridges the gap between current and future state, reducing variation, inventory levels, and system flexibility. Studies have shown that VSM can reduce system waste, minimize resources, and optimize performance. It is a proactive approach that helps choose the best technological approach at the beginning of a project[23].

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What is Value Stream Analysis?

Planning tool to optimize results of eliminating waste.

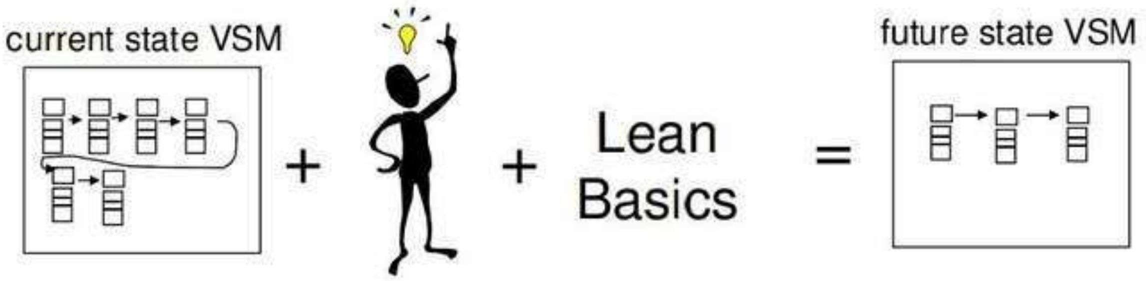

Figure 1: Value Stream Analysis. [24]

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METHODOLOGY

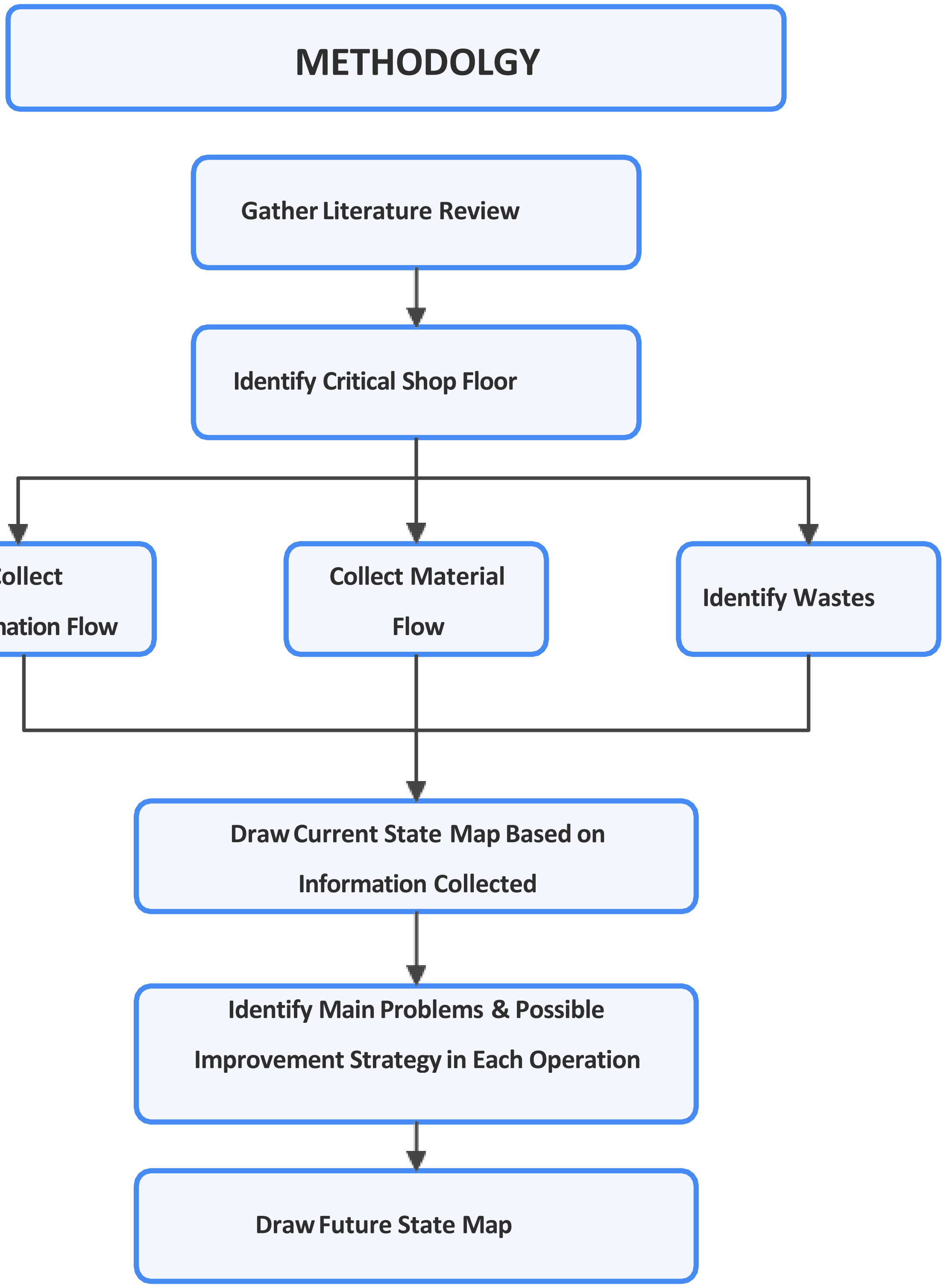

Figure 2: Research Methodology

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Time Study

"Frederick Winslow Taylor" created the "Time Study" method to establish benchmark times for various tasks or projects. Time studies are typically conducted in environments with repeating work cycles that range in length from short to long and where there are many different types of work. This is because time studies require participants to observe an activity directly and continuously while also using a timekeeping device to track how long it takes to complete a task[25].

An examination of how time is used can lead to the creation of standards for directing or controlling performance as well as a set of standards for directing efforts to improve current circumstances. In the absence of basic time study data, it is impossible to assess whether a task or piece of work has improved over time or whether there are variations in how well it is completed within a unit. As a result, through time study, we carefully analyze the task or activity to minimize or eliminate any unnecessary aspects of the work involved and then approach the task or activity in the best way possible[26].

Stopwatch and time study forms or sheets make up the time study equipment used in this study.

A reliable clock with a second-hand clock and a calculator should also be present in the study. The time study forms or sheets are used to record the observations made during the time study and the stopwatch is used to calculate or measure how long it takes to complete the specific activity. As a result, all the crucial information about the time study is recorded on the time study methods or sheets of material[27].

Software Used in the Study

In this research, used Edaw max and Visio software to make Value Stream Mapping of Current and Future state and Production Flow.

Control Charts

A particular type of chart used to examine how the data varies over time is the control chart. In Excel, it is also referred to as a behavioral chart or Shewhart chart. It is used in business statistics to assist users or viewers in analyzing how any process changes. Its components are the control line, as well as the upper and lower control lines, and it is made with the aid of computations of the data's average and standard deviation.

Data Collection and Analysis

The data collection and analysis framework in research focused on Value Stream Mapping (VSM). VSM is a powerful lean management tool used to analyze and improve the flow of materials and information in a process or value stream. It helps identify waste, bottlenecks, and opportunities for improvement. Data collection and analysis play a crucial role in VSM research to gather relevant information, identify process inefficiencies, and make data-driven decisions for process improvement.

The following framework outlines the key steps involved in collecting and analyzing data for a research thesis on VSM.

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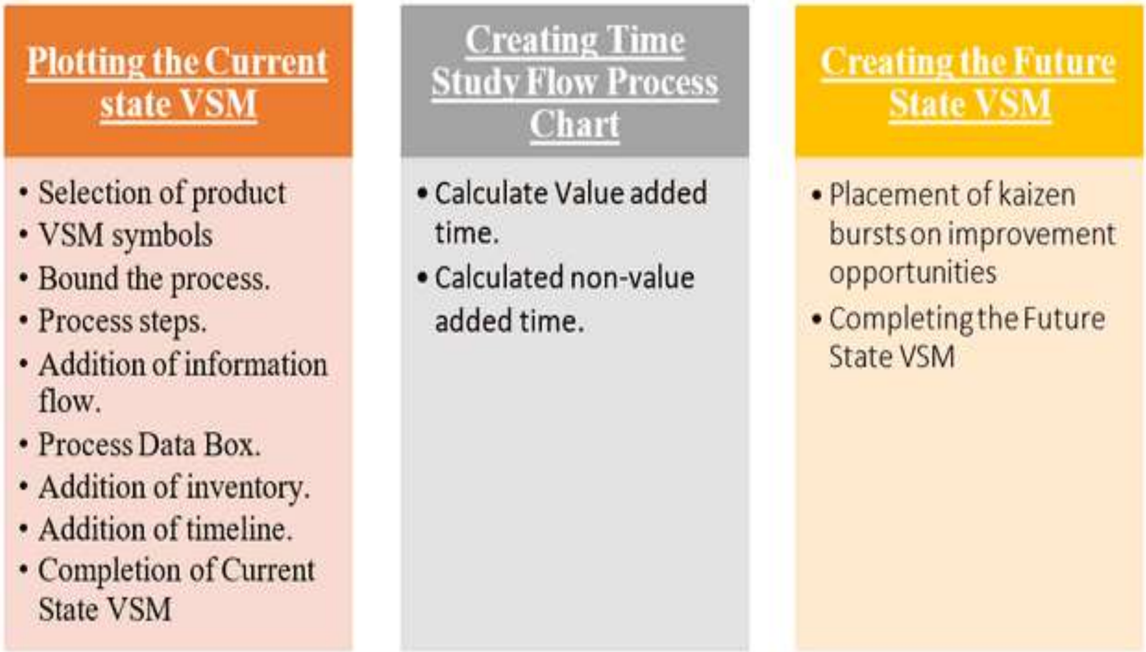

Figure 3: The Framework for VSM

On the Company Building's First floor (Pakistan), various products are being produced, out of which the Stitching department was selected for this study. It's needed to decide the limits of our map to bind the process. The study considers in stitching department on the Duvet object and to improve their process. But In Value Stream Mapping current and future Value Stream Mapping has been written all the processes from start to end.

In addition to information flow in this step how the customer places the order and how it is transported to the supplier. In the Manufacturing industry gives orders to the production department based on the weekly plan. Therefore, it was considered an electronic information flow hence the symbol was used accordingly. Inside the factory, Information flow starts by generating material requisition numbers from the production team, proceeds through confirmation at the store, and ends when a Material Receipt Note (MRN) is received at company unit 01 FWH (WAREHOUSE). A manual information flow icon was used to represent this flow because MRN is manually written, authorized, and handled throughout the flow.

Process the Data Box: recording actual data at the working area, we tried to avoid “historical” data where possible, noticing current information. For this research, the data required was cycle time, batch size, packet size, and number of workers required to perform the activity. This data was recorded in the “data boxes” placed below process boxes on our Value Stream Map, as shown in Figure 4.

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Data Box
Cycle time
Frequency
Batch size
No: of workers
Total Production

Figure 4: Process Data Box

The addition of inventory during the processes, wherever it is seen, is the fourth step. Inventory was seen at four locations, which are divided into three categories: storage, work-in-progress, and finished goods inventory (not including the main warehouse, which we regarded as the supplier). The current state map has a timeline that can be used to determine both the lead time and the total cycle duration. Both the value-added and non-value-added times were shown on the timelines. The peaks on the timeline represent the times that added value, while the valleys on the timeline represent the times that did not.

The final step is to add more symbols to the current state map, such as quality checks, transport, push or pull arrows, and operator symbols, to represent activities besides processes and inventories. These symbols were added, and the result was a current state value stream map, as seen in the figure below.

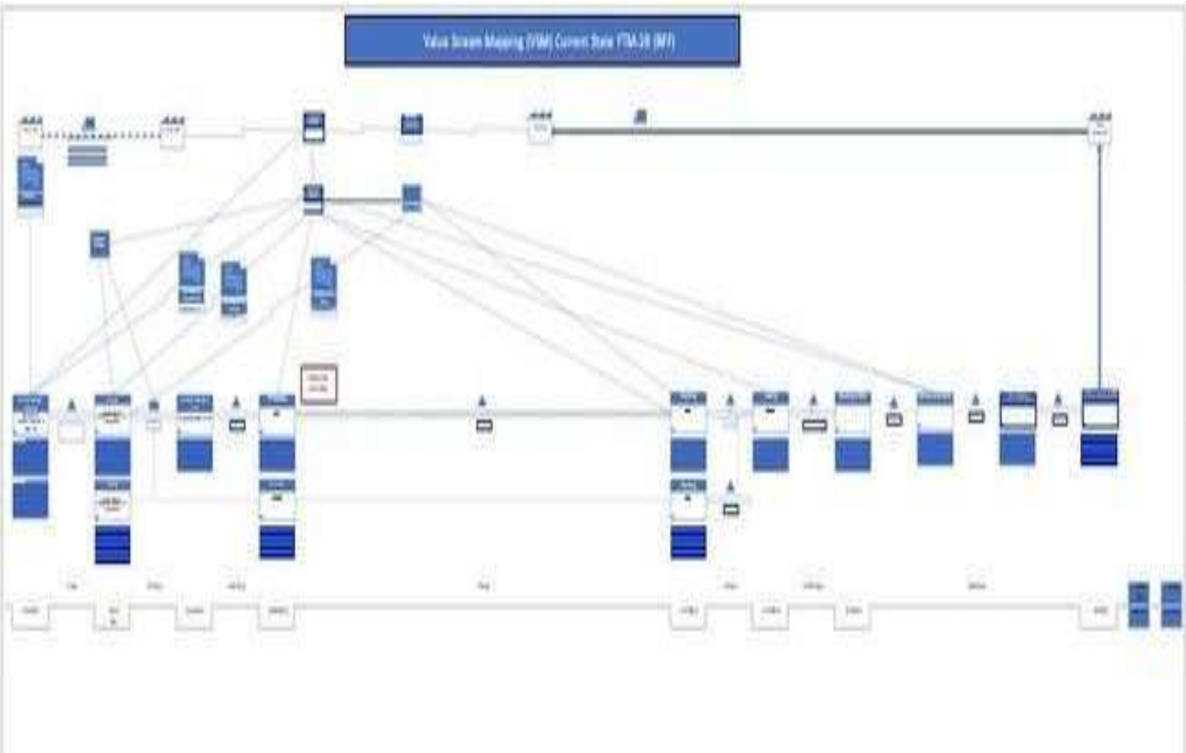

Figure 5: Current Value Stream Mapping of Company

Interpreting the Current State Value Stream Map

Current state VSM represents the flow of information and flow of material throughout the value stream. It assisted in identifying non-value-added activities. This research focused on some

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processes but main focus in Stitching i- e; Line Balancing and Cutting Stitching processes. Each process is explained in detail with a flow diagram and time for each activity involved in it.

Cutting Process Department

The following figure shows the process of cutting the department. Various steps are included in the department and those are followed by each article during the cutting process.

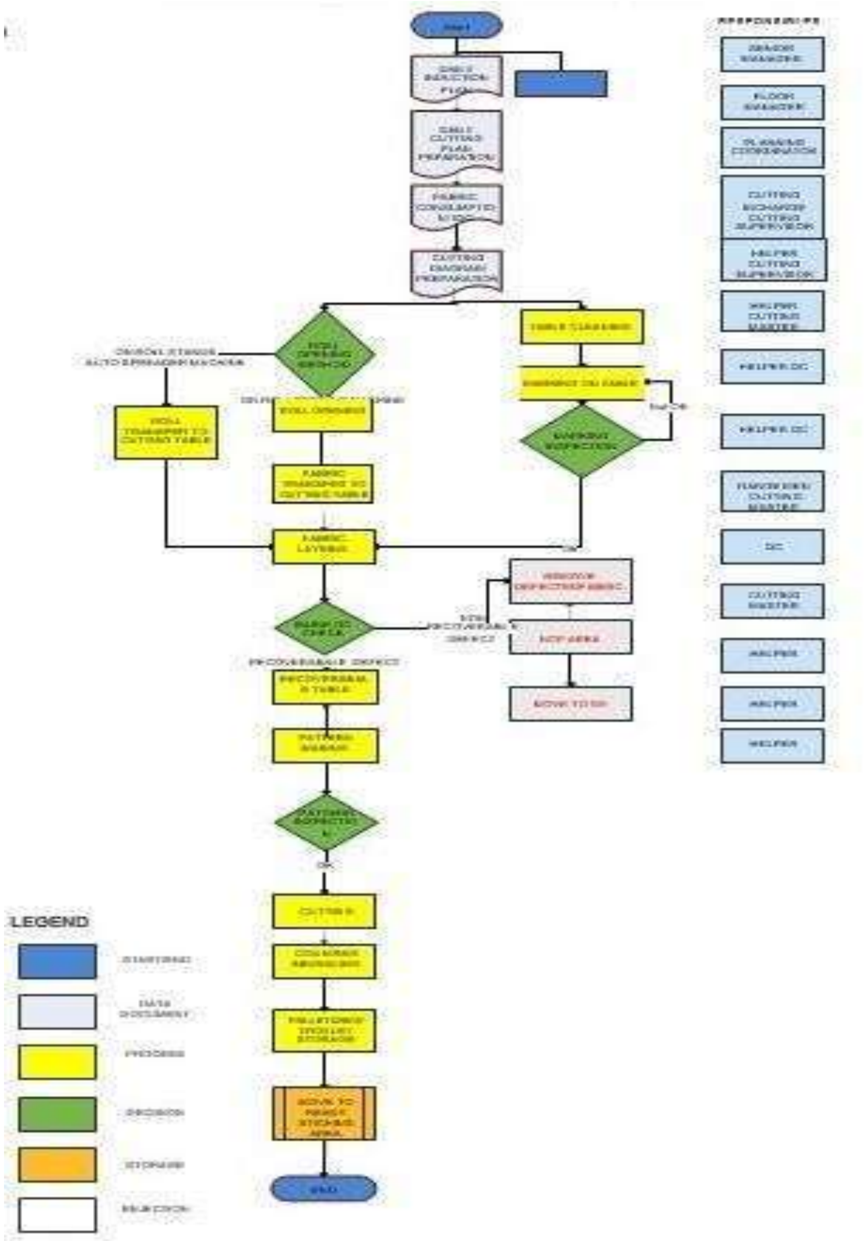

Figure 6: Cutting Process

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Cutting Data Formulas

- $Total\ time\ of\ 1\ range\ (min) = \frac{cycle\ time\ of\ layer\ (s) * \text{No of layers in 6 inch}}{60}$
- $Total\ production\ meters/CT = \text{No of Layers in 6 inches} * \text{No of Meters}$
- $Cycle\ time\ of\ 1\ range\ in\ Hours = (Total\ time\ of\ 1\ range + marking\ time + machine\ cutting\ time + bundling\ time)/60$
- $Total\ ranges = \frac{Working\ Hours}{Cycle\ time\ of\ 1\ Range}$
- $Total\ Production\ Meters = Total\ Ranges * Total\ Production\ Meters/CT$
- $Total\ Production\ Pcs = \frac{Total\ production\ Meters}{No\ of\ Meters}$
- $\text{Efficiency} = \frac{Actual\ Production}{Total\ Production/Day}$

Table 1: Cutting Data

Operations	Table 1
Article	Duvet Front
Manpower	4
No Of Layers In 6 Inch Height	80
No Of Meters	3.5
Cycle Time of Layer (Sec)	10
Total Time Of 1 Range (Min)	13
Marking Time (Min)	8
Relaxation Time (Min)	-
Machine Cutting Time (Min)	8
Bundling Time (Min)	20
Total Production Meters/Ct	280
Cycle Time Of 1 Range (Hrs.)	0.82
Total Ranges	9.12
Total Production Meters/Day	2554
Grand Total Production/Day	730
Actual Production	700
Efficiency	96%

Operations	Table 2
Article	Duvet Reverse
Manpower	4
No Of Layers In 6 Inch Height	300
No Of Meters	3.5
Cycle Time of Layer (Sec)	20
Total Time Of 1 Range (Min)	100
Marking Time	9
Relaxation Time (Min)	-
Machine Cutting Time (Min)	9
Bundling Time	25
Total Production Meters/Ct	1050
Cycle Time Of 1 Range (Hrs.)	2.38
Total Ranges	3.15
Total Production Meters/Day	3304
Grand Total Production/Day	944
Actual Production	850
Efficiency	90%

The above table shows the cutting data of two different articles, in the table different operations

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ISSN 2518-4709 (Online)
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are included.

Stitching Process Department

The following figure shows the process of stitching the department. Various steps are included in the department and those are followed by each article during the stitching process.

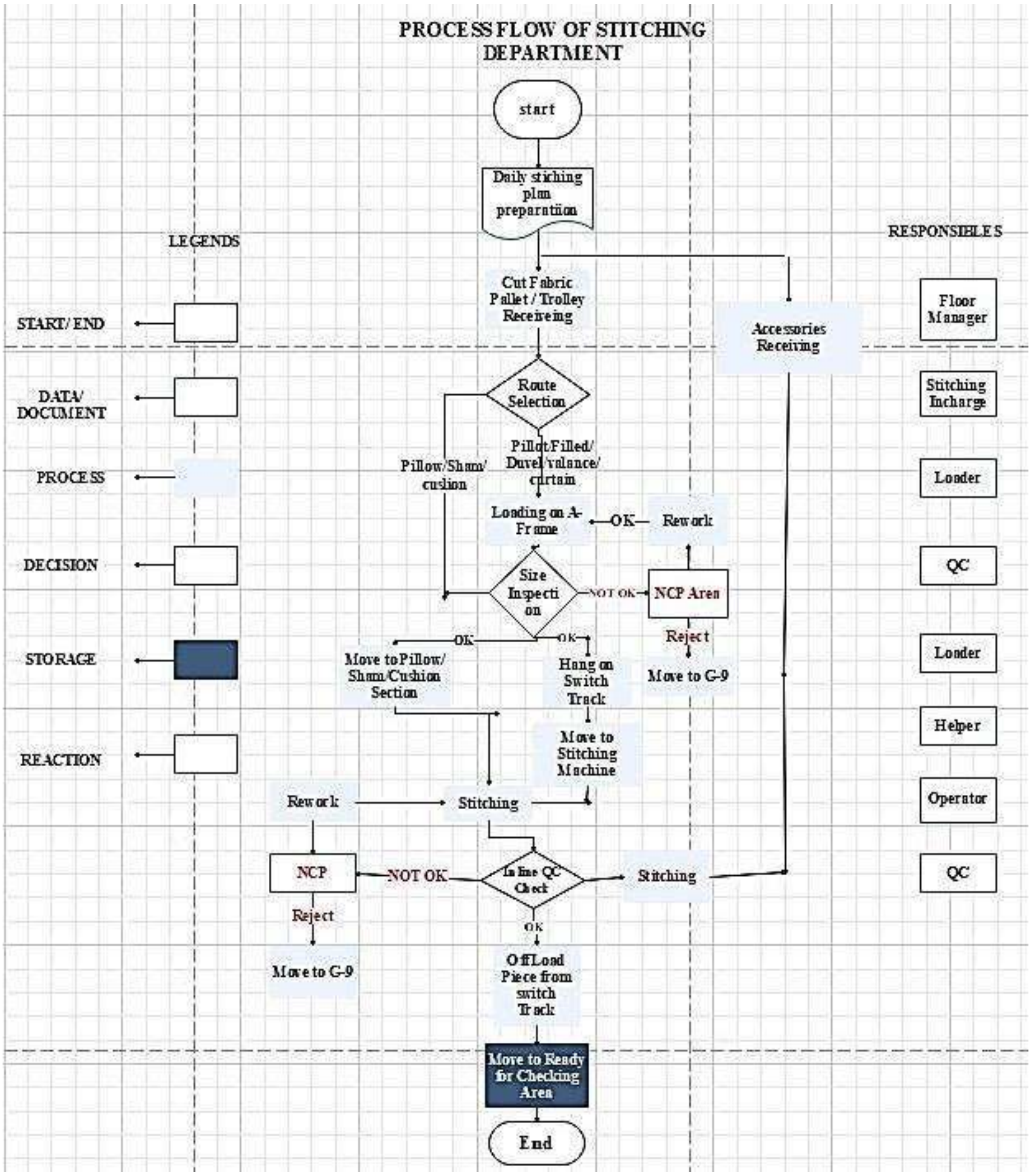

Figure 7: Stitching Process Department

Process of Flow of F Fabric Receiving, Issuance and Return

In this process, analyze the whole process of where are from the flow of fabric receiving,

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and issuance and then the return process.

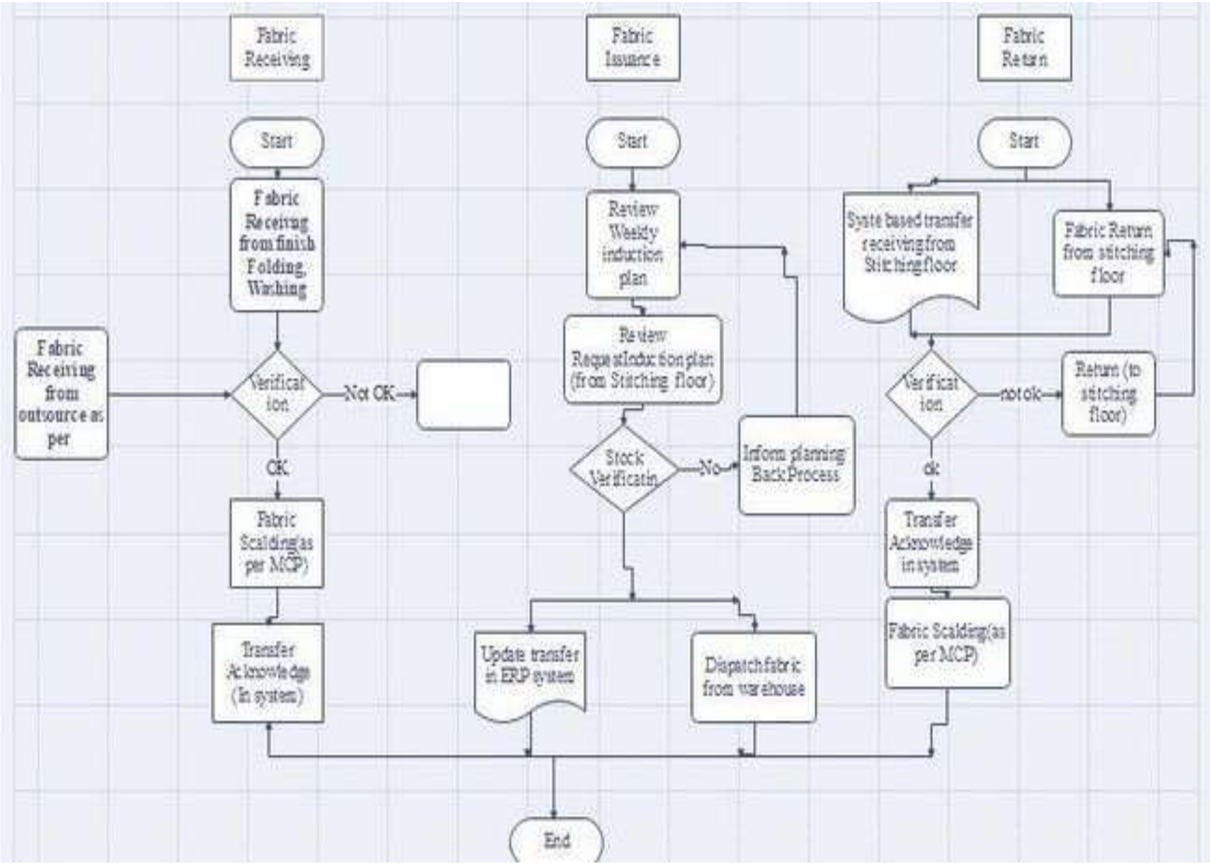

Figure 8: Process of Flow of F Fabric Receiving, Issuance and Return

Before Line Balancing of Stitching of Duvet:

The organization of machine capacity in a layout to ensure a reasonably uniform flow at capacity operation is known as line balancing.

In Before Line balancing, the total production is less, and takt time is more according to the production.

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Table 2: The results before Line Balancing of Stitching of Duvet

PIPING DUVET									
Operational Details	SPI	8	Efficiency	85%	Size	ALL		Cell Output	8
	Article	Operation Name	Machine	Avg SAM	Hourly Output/ Mc	Cell Output Per Day	Machines req.	Total production/shift	Working hrs./shift
STITCHING	DUVET	PIPING ATTACHMENT 4 SIDE	SNLS	1.53	33	250	3	750	7.5
		PIPING TACKING	SNLS	0.25	204	1530	1	1530	7.5
		1 SIDE PATTA ATTACHMENT	SNLS	0.72	71	531	2	1063	7.5
		OVERLOCK 1 SIDE	3T O/L	0.42	121	911	2	1821	7.5
		HEM 2 SIDE	SNLS	0.35	146	1093	1	1093	7.5
		SHOULDER TACKING 2 SIDES	SNLS	0.58	88	659	1	659	7.5
		ASSEMBLE 4 SIDE	SNLS	2.62	19	146	5	730	7.5
		OVERLOCK 4 SIDE	3T O/L	1.01	50	379	1	379	7.5
		KAJ MAKING	Kaj	0.6	85	638	1	638	7.5
		BUTTON ATTACHMENT	Button	0.55	93	695	1	695	7.5
		CHECKING	Manual	2.2	23	174	4	695	7.5
		Total		10.83	19		22	379	

RESULTS

Table 3: Results of Piping Duvet-Glamour Oxford before line balancing

PIPING DUVET - GLAMOUR OXFORD	
SAM (min)	**10.83**
Number of machines	**18**
Total Production Capacity/Cell (Pcs)	**635**
Per Hour Pcs Per Cell (Pcs)Number of pieces per hour	**50**

The above table is of piping duvet glamour oxford before line balancing. In the table the SAM is 10.83 Min, 18 machines are used, the total production capacity per cell(pieces) is 635, and 50 pieces are per hour per cell.

Stitching Data Formulas

- $SAM = NORMAL\ TIME * PERFORMANCE\ RATING + ALLOWNCE\ (BH + PF)$
- $SAM = NORMAL\ TIME * 0.85 + NORMAL\ TIME * 0.85\ (17.5\%)$
- $SAM = NORMAL\ TIME * 0.85\ (1.175)$
- $PRODUCTION\ OR\ TARGET = \frac{WORKING\ MINTUES * 0.85 * NO\ OF\ MACHINES}{SAM}$
- $NO\ OF\ MACHINES = \frac{TARGET * SAM}{WORKING\ MINTUES * 0.85}$

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After Line Balancing Stitching of Duvet: In After Line Balancing, we precise and arrange the machine process sequences and increase the total production per pics in the required time.

Table 4: After Line Balancing of Stitching of Duvet

PIPING DUVET									
Operational Details	SPI	8	Efficiency	85%	Size	ALL		Cell Output Per Day	8
	Article	Operation Name	Machine	Avg SAM	Hourly Output/Mc	Cell Output Per Day	Machines req.	Total production /shift	Working hrs./shift
STITCHING	DUVET	PIPING ATTACHMENT 4 SIDE	SNLS	1.53	33	250	3	750	7.5
		PIPING TACKING	SNLS	0.25	204	1530	1	1530	7.5
		1 SIDE PATTA ATTACHMENT	SNLS	0.72	71	531	2	1063	7.5
		OVERLOCK 1 SIDE	3T O/L	0.42	121	911	1	911	7.5
		HEM 2 SIDE	SNLS	0.35	146	1093	1	1093	7.5
		SHOULDER TACKING 2 SIDES	SNLS	0.58	88	659	1	659	7.5
		ASSEMBLE 4 SIDE	SNLS	2.62	19	146	5	730	7.5
		OVERLOCK 4 SIDE	3T O/L	1.01	50	379	2	757	7.5
		KAJ MAKING	Kaj	0.6	85	638	1	638	7.5
		BUTTON ATTACHMENT	Button	0.55	93	695	1	695	7.5
		CHECKING	Manual	2.2	23	174	4	695	7.5
		Total		10.83	19		22	638	

Table 5: Results after Line Balancing

PIPING DUVET - GLAMOUR OXFORD	
SAM (min)	**10.83**
Number Of machines	**18**
Total Production Capacity/Cell (Pcs)	**636**
Per Hour Pcs Per Cell (Pcs)	**85**

The above table is of piping duvet glamour oxford before line balancing. In the table the SAM is 10.83 Min, 18 machines are used, the total production capacity per cell(pieces) is 636, and 85 pieces are per hour per cell. Look now at the new production capacity is changed and pieces per hour are increased on the same machines and SAM. Here means considering the number of pieces is increasing at the same machines and SAM. The total production is increasing means first was less but after line balancing total production increased.

Before Line Balancing of Stitching and Checking of SHAM

Table 6: Before Line Balancing of Stitching and Checking of SHAM

BEFORE LINE BALANCING								
Operational Details	SPI	8	Efficiency	85%	Size		Total Production Capacity/Cell	2125
	Article	Operation Name	Machine	Avg SAM	Hourly Output/Mc	Machines req.	Total production/shift	Working hrs./shift
STITCHING & CHECKING	SHAM	2 SIDE HEM + LABLE	SNLS	0.15	340	1	2550	7.5
		ASSEMBLE 4 SIDE	SNLS	0.95	54	5	2013	7.5
		CUTTING 4 SIDE	S/F	0.20	255	1	1913	7.5
		TURNING	Manual	0.14	364	1	2732	7.5
		OVERLOCK 4 SIDE	SNLS	0.50	102	3	2295	7.5
		CHECKING	Manual	0.37	138	2	2068	7.5
	Total			1.80	54	10	1913	

WAFFLE SHAM	
SAM(min)	1.80
No. of machines	10
Total Production Capacity/Cell (Pcs)	2125
Per Hour Pcs Per Cell (Pcs)	283

The above table shows data on stitching and checking of SHAM before line balancing. In the table the SAM is 1.80 Min, 10 machines are used, the total production capacity per cell(pieces) is 2125, and 283 pieces per hour per cell.

After Line Balancing of Stitching and Checking of SHAM

Table 7: After Line Balancing of Stitching and Checking of SHAM

AFTER LINE BALANCING								
Operational Details	SPI	8	Efficiency	85%	Size		Total Production Capacity/Cell	1747
	Article	Operation Name	Machine	Avg SAM	Hourly Output/Mc	Machines req.	Total production/shift	Working hrs./shift
STITCHING & CHECKING	SHAM	2 SIDE HEM + LABLE	SNLS	0.15	340	1	2550	7.5
		ASSEMBLE 4 SIDE	SNLS	0.95	54	4	1611	7.5
		OVERLOCK 4 SIDE	S/F	0.50	102	2	1530	7.5
		CHECKING	Manual	0.37	138	2	2068	7.5
	Total			1.97	54	9	1530	

GLAMOUR OXFORD	
SAM(min)	1.97
No. of machines	9
Total Production Capacity/Cell (Pcs)	1747
Per Hour Pcs Per Cell (Pcs)	233

International Journal of Supply Chain Management
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The above table shows data on stitching and checking of SHAM after line balancing. In the table the SAM is 1.97 Min, 9 machines are used, the total production capacity per cell(pieces) is 1747, and 233 pieces per hour per cell. Here the number of machines decreased, SAM increased, production capacity decreased, and per-hour pieces were also decreased. Due to the decrease in machines other operations are decreased. The total production is also increasing look at table.

Before Line Balancing of Packaging of Duvet Set

Table 8: Before Line Balancing of Packaging of Duvet Set

BEFORE LINE BALANCING									
Operational Details	SPI	8	Efficiency	85%	Size		Total Production Capacity/Cell	1536
	Article	Operation Name	Machine	Avg SAM	Hourly Output/Mc	Menpower req.	Total production/ shift	Working hrs./shift
PACKING	DUVET SET	DUVET FOLDING WITH STIFFNER	Manual	0.30	170	1	1275	7.5
		PASSING THROUGH MDM	Manual	0.12	425	1	3188	7.5
		PILLOW PAIRING/FOLDING + SET MAKING	Manual	0.35	146	1	1093	7.5
		RIBBON ATTACH IN INLAY CARD + RFID STICKER PASTING	Manual	0.28	182	1	1366	7.5
		DUVET INSERTING IN RIBBON	Manual	0.17	300	1	2250	7.5
		BACK INLAY CARD ATTACH + RIBBON SETTING	Manual	0.91	56	1	420	7.5
		INSERTING IN POLYBAG & FLAP CLOSING	Manual	0.35	146	1	1093	7.5
		CARTON FILLING	Manual	0.11	464	1	3477	7.5
		CARTON SEALING	Manual	0.15	340	1	2550	7.5
	Total			2.74	56	9	420	

NORMAL DUVET PACKING	
SAM(min)	2.74
No. of persons	11
Total Production Capacity/Cell (Pcs)	1536
Per Hour Pcs Per Cell (Pcs)	205

The above table shows data on packing before line balancing. In the table the SAM is 2.74 Min,11 persons are working, the total production capacity per cell(pieces) is 1536, and 205 pieces per hour per cell.

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After Line Balancing of Packaging of Duvet Set

Table 9: After Line Balancing of Packaging of Duvet Set

AFTER LINE BALANCING								
Operational Details	SPI	8	Efficiency	85%	Size		Total Production Capacity/Cell	1536
	Article	Operation Name	Machine	Avg SAM	Hourly Output/Mc	Menpower req.	Total production/shift	Working hrs./shift
PACKING	DUVET SET	DUVET FOLDING WITH STIFFNER	Manual	0.30	170	1	1275	7.5
		PASSING THROUGH MDM	Manual	0.12	425	1	3188	7.5
		PILLOW PAIRING/FOLDING + SET MAKING	Manual	0.35	146	1	1093	7.5
		RIBBON ATTACH IN INLAY CARD + RFID STICKER PASTING	Manual	0.28	182	1	1366	7.5
		DUVET INSERTING IN RIBBON	Manual	0.17	300	1	2250	7.5
		BACK INLAY CARD ATTACH + RIBBON SETTING	Manual	0.91	56	2	841	7.5
		INSERTING IN POLYBAG & FLAP CLOSING	Manual	0.35	146	1	1093	7.5
		CARTON FILLING	Manual	0.11	464	1	3477	7.5
		CARTON SEALING	Manual	0.15	340	1	2550	7.5
		Total		2.74	56	10	841	
		NORMAL DUVET PACKING						
		SAM(min)	2.74					
		No. of persons	11					
		Total Production Capacity/Cell (Pcs)	1536					
		Per Hour Pcs Per Cell (Pcs)	205					

The above table shows data on packing after line balancing. In the table the SAM is 2.74 Min,11 persons are working, the total production capacity per cell(pieces) is 1536, and 205 pieces per hour per cell. But now look at the table on the same number of persons the production is increasing.

Overall Observations

To obtain precise data on industry cycle durations, performed time studies for this research. The study separated the procedures into various tasks and determined the duration of each task. The time studies in the stitching department provided us with the actual cycle times for every activity. The process of closely monitoring and documenting human labor to determine how long it takes to complete a task is known as a time study. Within the stitching department, conducted time studies and recorded thing cycle times for each operation using pre-made tables and a stopwatch, as seen above. The study utilized the crucial information these cycle times provided to us in our VSM. To determine which actions, bring value and which do not. The production per cell changes both before and after the balancing line, and the cycle duration increases because of the increased production and removal of certain non-value-added motions.

Creating the Future State Value Stream Mapping

Following some discussion, the present state of VSM was examined; very few possible outcomes were found. A future state VSM with a kaizen burst to show the amount of NVA time and the potential for improvement. The future state map is a conceptual representation of a possible future that was made to gather feedback. The Steam map offers the best value in terms

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of cost. The ongoing pursuit of improvement is the main goal of the future state map. Achieved this by reducing the time spent on non-value-adding tasks, the work-in-process inventory, the workforce, and the process.

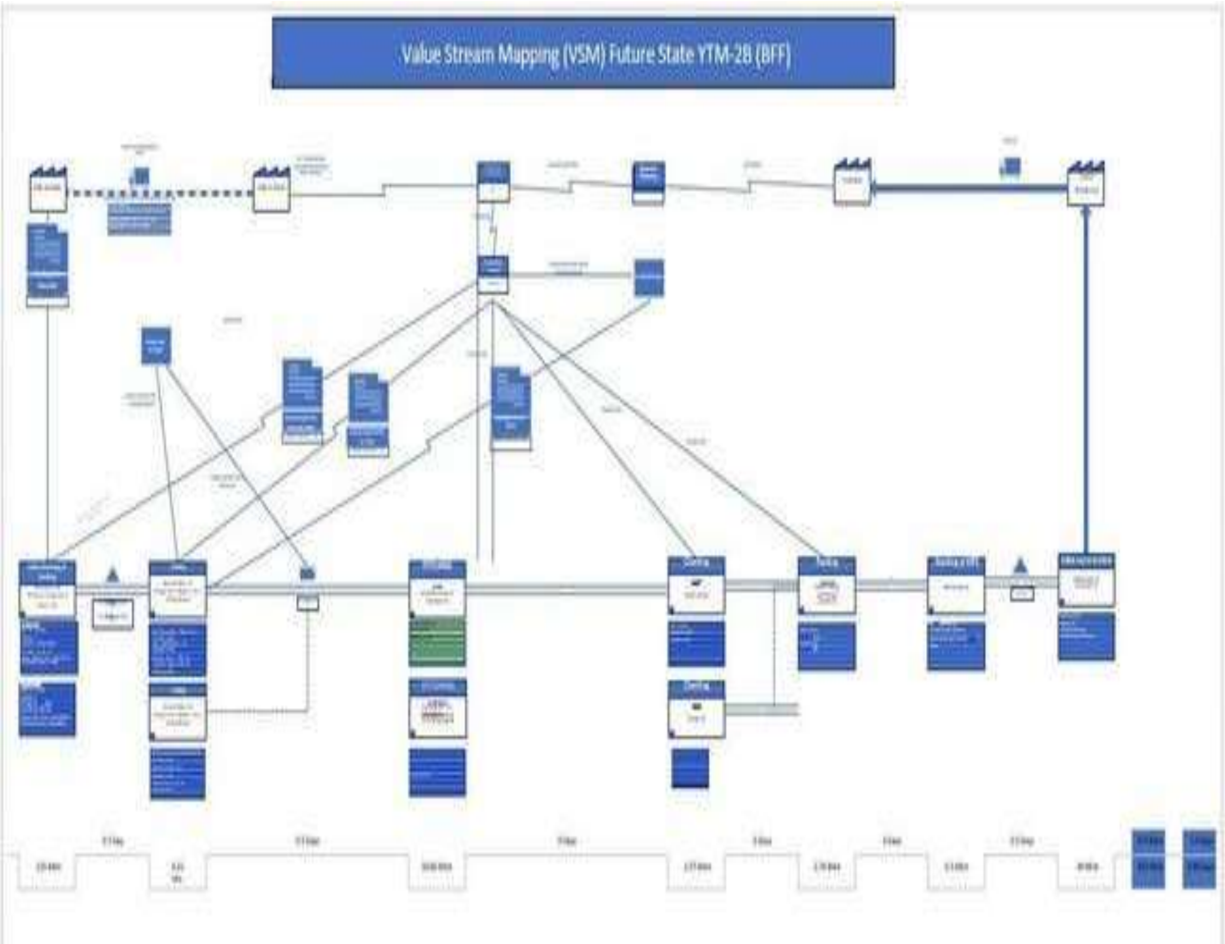

Figure 9: Creating Future VSM

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Results and Analysis of Current and Future Value Stream Mapping

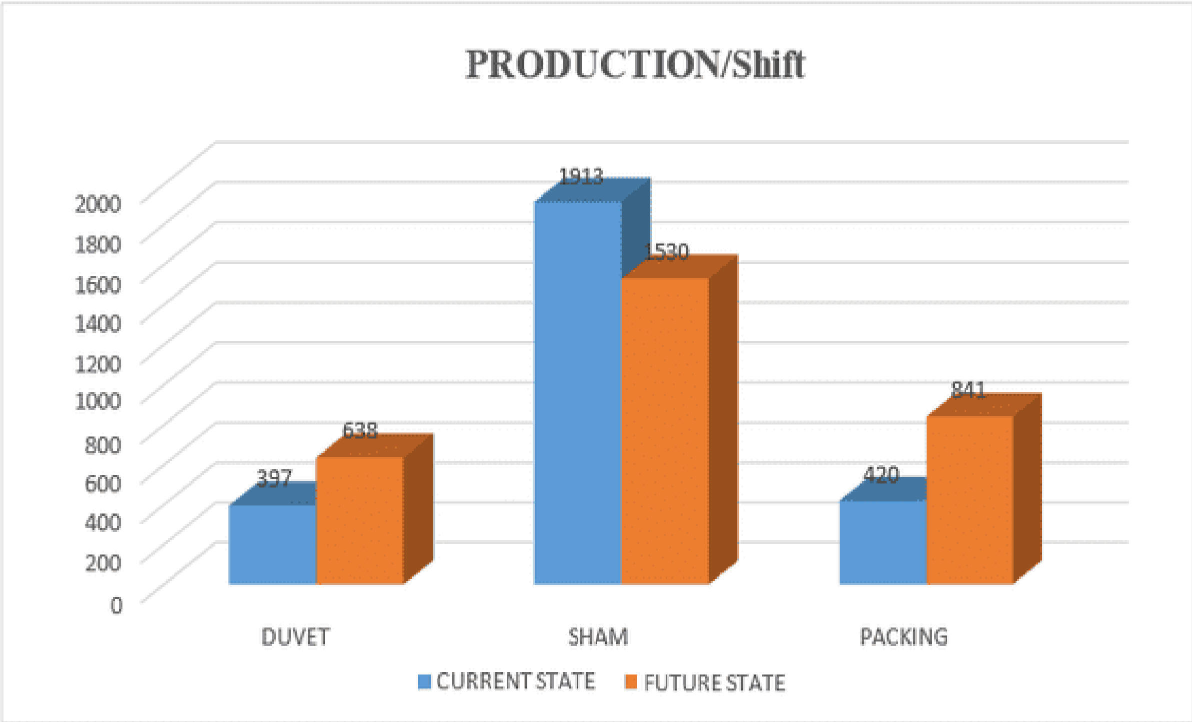

Figure 10: Compare Current and Future VSM in Production/Shift

The above graph suggests that VSM plays a crucial role in production, the figure shows in future the production can increase if the company implements the VMS technique.

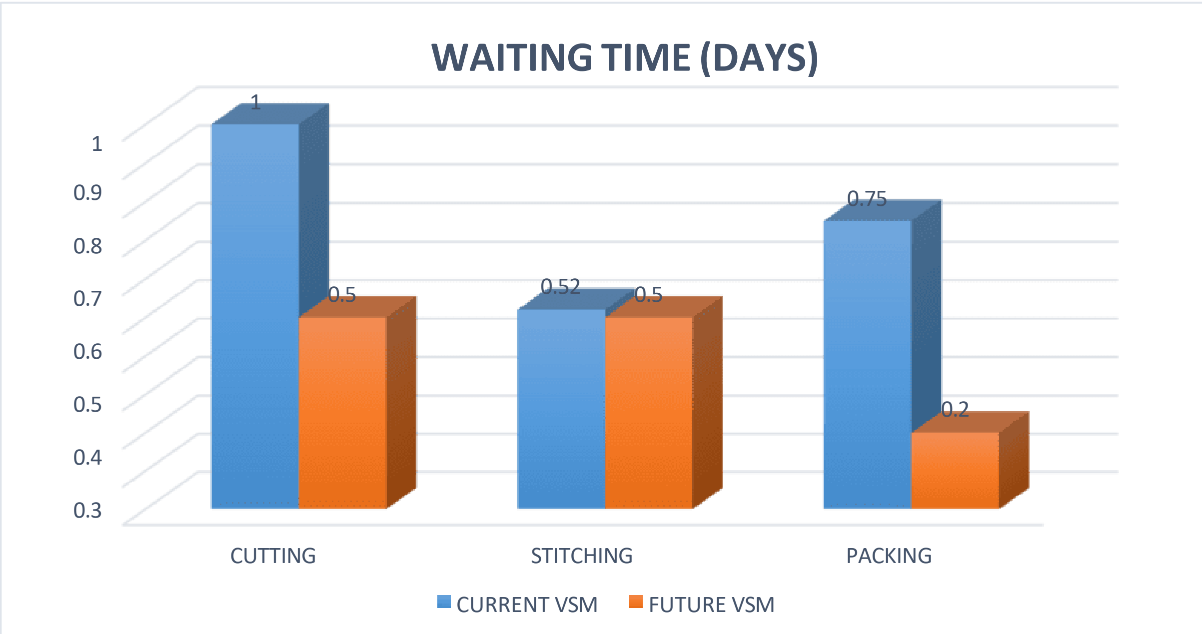

Figure 11: Compare Future and Current VSM Waiting Time (Days)

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The above figure shows current waiting time is high so in the future if the company implements the VMS technique, then the waiting time will decrease.

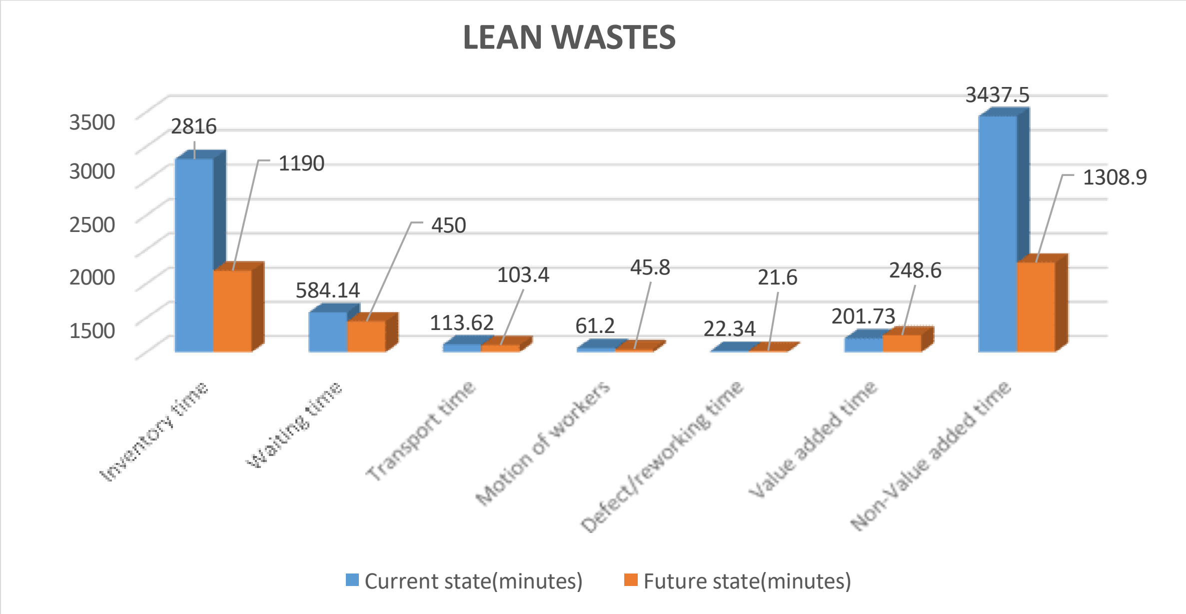

Figure 12: Compare Current and Future VSM of Lean Wastes

The above figure shows current waste is high so in the future if the company implements the VMS technique, then the lean waste will decrease.

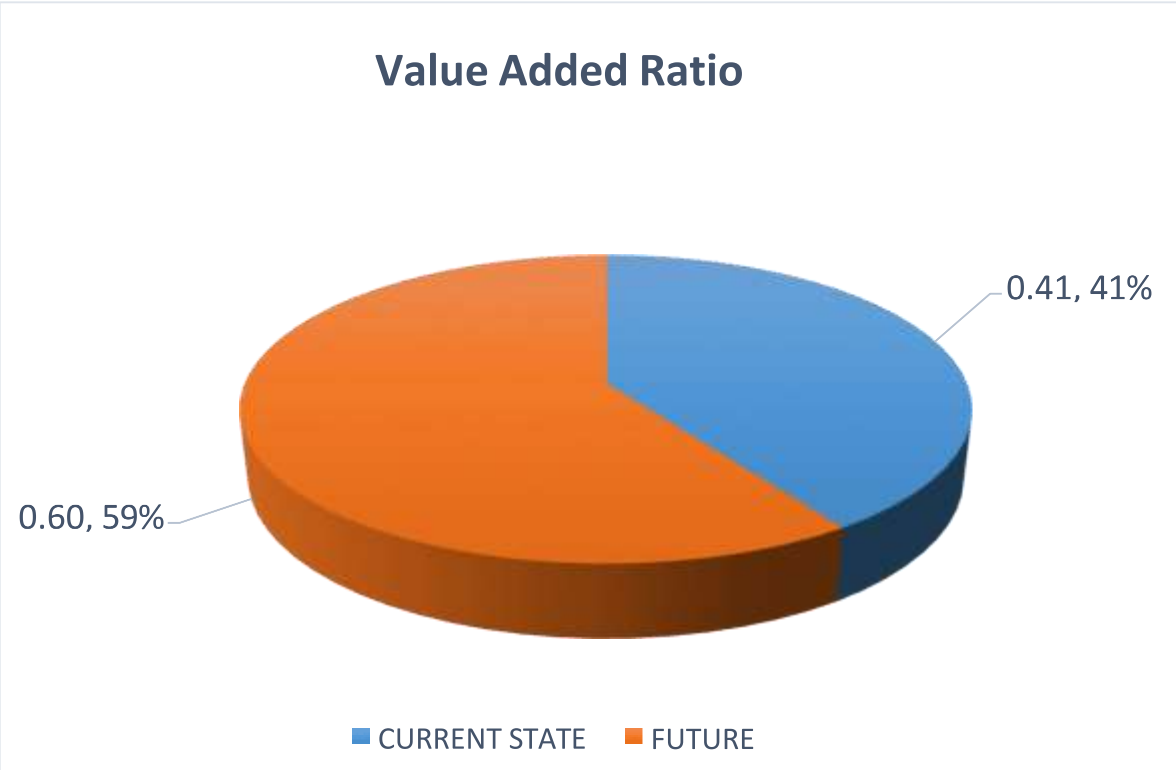

Figure 13: Graph of Value-Added Ratio Compare of Current and Future VSM

The above graph shows the comparison of the value-added ratio of current and future VSM.

CONCLUSION AND RECOMMENDATIONS

Conclusion

Based on the analysis/results of this study, it is concluded that the VSM can be a simple and effective tool for the Textile industry to visualize & analyze the Lean wastes that occur in information, production & material flow. It is also observed that the traditional way to develop VSM is time-consuming and due to its static nature sometimes it fails to provide the eye bird view of whole the system with accurate & reliable data. Hence Future work could focus on creating a unified dashboard where the diagram as well as the comparisons of future & current state maps can be digitized/displayed in one place to analyze the lean wastes and performance of the overall production unit.

Recommendation

The revolution of Industry 4.0 emphasizes the methods of obtaining digital data to provide dynamic & quick solutions to the problems faced by the industries. Hence it is suggested that the process of VSM should be digitized to visualize and analyze the lean wastes.

As of now, VSM seems to be the most effective tool to fulfill most of the objectives of lean manufacturing systems. Hence it is suggested that the Pareto & OEE analysis followed by VSM should be mandatory to achieve the high-quality performance of Lean systems.

It is also noticed that implementation of the future state of VSM requires the process of re-engineering, so it is suggested that long-term training is mandatory to be given to the employees for better results of improvement opportunities.

It is also reported that the focus of many researchers & practitioners remains the reduction of lean waste in the production area of the company. Hence it is suggested that supply & transportation are also potential areas for the reduction of lean waste to improve customer service.

Recommendations

To transform the value stream holistically Expansion of Lean Principles Consider the advantages of incorporating pull systems and just-in-time (JIT) inventory management into the cutting, checking, and packing processes. Develop training programs to ensure that all staff members are aware of lean processes and are capable of actively participating in them. Implementing employee engagement initiatives will help to promote a culture of continuous improvement. To improve material flow within the stitching section, investigate the use of Kaizen or other inventory control techniques. The research focuses on eliminating the lean waste unlined-balancing issues and non-value-added ratio. And analyses the results through graphs. This study improved the building's first-floor nonvalue-added activities and unlined balancing issues. Further, work on this topic and can focus on the different production areas like stitching checking Quality control, and so on.

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