

LEAN MANUFACTURING ANALYSIS WITH WASTE ASSESSMENT MODEL (WAM) APPROACH TO REDUCE CRITICAL WASTE IN THE PRODUCTION PROCESS OF WOVEN SARONG CV. XYZ

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Abstract

The manufacturing industry faces challenges to improve efficiency and productivity amid increasingly fierce global competition. This study aims to analyze waste in the sarong weaving production process at CV. XYZ is using the Lean Manufacturing approach with the Waste Assessment Model (WAM) method. The results showed that the two most critical types of waste were transportation (20.95%) and inventory (20.64%). The root causes of transportation waste include inefficient fabric movement and narrow transportation lanes, while inventory waste is caused by the accumulation of goods in process (WIP) and the policy of purchasing raw materials in large quantities. The proposed improvements include layout optimization, efficient means of transportation, inventory management training, and line balancing implementation. The recommendations are projected to reduce production lead time by 13.60%, from 1,265 minutes to 1,093 minutes. This research makes a significant contribution to the application of Lean Manufacturing in the traditional textile industry.

Keywords: Lean Manufacturing, Production Efficiency, Waste Assessment Model, Waste Reduction, Woven Sarong

INTRODUCTION

In the era of globalization and increasingly fierce business competition, the manufacturing industry is faced with demands to continue to innovate in its production processes. These innovations aim to meet dynamic market demands while maintaining competitiveness. However, various challenges often hamper efficiency improvements, such as low productivity, operational inefficiencies, lack of labor qualifications, and limited access to modern technology (Istiqomah et al., 2023). One strategic approach to overcome these challenges is through identifying and managing waste in the production process. Lean manufacturing is the most widely applied method to reduce waste while building a more efficient production system. This approach aims to create an optimal workflow by producing products at the speed of customer demand and minimizing waste (Nurulita, 2024).

CV. XYZ, a textile manufacturing company that has been established since 1966, is known for its flagship product, the traditional woven sarong. By combining traditional art and modern technology, CV. XYZ's woven sarong products have successfully penetrated both domestic and international markets, including Malaysia, Brunei Darussalam, the Middle East, and Africa. However, along with the increasing variety of products and the high complexity of the production process, the company faces challenges to maintain production stability and efficiency.

The production process of woven sarongs at CV. XYZ involves quite long stages, starting from the winding process, basic coloring, to sewing and product quality inspection. Based on production data, in any given month, the company is only able to achieve 79% of its full production capacity. This condition indicates that there is capacity that has not been optimally utilized, which is largely due to the long production time caused by waste in the production process.

Waste that occurs refers to the concept of 7 wastes in Lean Manufacturing, such as waste motion, transportation, and waiting. Therefore, a systematic approach is needed to identify the most critical wastes and determine their root causes. The Waste Assessment Model (WAM) is used to evaluate the impact of waste on the efficiency of the production process. Furthermore, root cause analysis with fishbone diagram is applied to explore the main causes of the waste (Novitasari & Iftadi, 2021).

Through this approach, this research aims to develop measurable and targeted improvement proposals to improve the efficiency of the woven sarong production process at CV. XYZ. It is expected that the results of this study can make a significant contribution in reducing waste and increasing the stability of the production process in the company.

REVIEW OF LITERATURE

Lean Concepts

The lean manufacturing assembly process was first developed by Toyota for the automotive industry. The main goal of lean production is to ensure that products are produced exactly as needed and in the right place, with a primary focus on reducing waste and accepting necessary changes throughout the process. Taiichi Ohno, the main creator of lean principles, realized that improving the smooth flow of high-quality products along the production line was not only important for reducing waste. This lean concept can be applied in both manufacturing and service industries. The importance of the lean concept is streamlining and efficiency, which is achieved by reducing non-value-added activities, or waste. By focusing on reducing waste, companies can improve their operational efficiency, both in production processes and service delivery. This concept is a broad approach and can be applied in various industries to create leaner and more efficient processes (Ernawati et al., 2024).

According to (Fathimah & Winarno, 2024) the purpose of implementing Lean management is to eliminate waste that exists in the process, so that activities that provide value can be recognized along the process flow. The lean concept, which is part of the Toyota Production System (TPS), is a concept that focuses on seven types of waste.

Lean Manufacturing

Lean Manufacturing is an approach to identifying and eliminating waste and understanding the factors that cause it through continuous improvement, so that companies can operate more efficiently and reduce lead times. This method focuses on reducing waste by distinguishing between value-added and non-value-added activities and emphasizes the importance of flow, quality improvement, and continuous improvement. By implementing Lean Manufacturing, companies can respond to variations in production, improve quality, lower costs, and reduce cycle times. This approach is used because of its focus on reducing

waste in the production line to support operational efficiency and effectiveness (Dian et al., 2023).

According to (Restuasih et al., 2024), Lean Manufacturing is an approach that focuses on reducing waste, continuous improvement, and improving the relationship between suppliers and consumers through better products and faster service. Its application helps companies reduce costs, reduce product defect rates, shorten lead times and cycle times, and reduce work in process (WIP) and non-value-adding activities. In addition, it improves productivity, workforce quality, and optimizes space and facilities.

Toyota Production System

The Toyota Production System (TPS), developed by Toyota Motor Corporation, is one of the most efficient and innovative manufacturing systems in the world. The system is based on lean manufacturing principles with the main objective of reducing waste that occurs during the production process. TPS is specifically designed to reduce lead times in the production process, although Taiichi Ohno, the originator of these principles, did not explicitly emphasize lead time reduction in his writings. His main focus is on the method to achieve it, which is through reducing various types of waste (Ihsan et al., 2023).

Value Stream Mapping

Value Stream Mapping (VSM) is a visual representation of all activities, both value-added and non-value-added, required to deliver goods or services to customers. VSM aims to map, identify, and eliminate waste along the production process or other activities and improve the overall flow. The focus is on improving overall performance, not just optimizing certain parts in isolation. The process involves two main steps: Current State Map, which describes the current state of the process flow and identifies waste, and Future State Map, as a design of improvements from the existing conditions (Arunizal et al., 2024).

According to (Restuasih et al., 2024), there are three main categories of activities in the production process. First, value-added activities (VAs) that provide value to customers and affect the final product. Second, non-value-added activities (NVA) that are not needed and must be eliminated to avoid waste. Third, activities that are not needed and do not provide value (NNVA).

Waste Assessment Model

Waste Assessment Model (WAM) is a model designed to facilitate the identification and elimination of waste in the production process. This model uses a waste assessment questionnaire to allocate waste that occurs in the production line, so that the identification process becomes more focused and effective. According to (Harsa et al., 2024), research with WAM requires clear and measurable objectives so that the desired results can be achieved properly. Meanwhile, (Naziihah et al., 2022) explained that WAM simplifies the waste identification process by mapping the relationship between seven types of waste: Overproduction (O), Process (P), Inventory (I), Transportation (T), Defects (D), Waiting (W), and Motion (M). The WAM process involves three main stages: creation of the Seven Waste Relationship (SWR), preparation of the Waste Relationship Matrix (WRM), and creation of the Waste Assessment Questionnaire (WAQ).

Fishbone Diagram

A Fishbone Diagram is also a structured visualization that depicts the various interrelated causes that affect a process. Each impact is grouped by cause categories, such as Manpower, Method, Materials, Machine, and Environment, which are depicted as small bones. Meanwhile, the main bone leading to the fish head illustrates the results of the analysis of the five categories as the root of the problem to improve quality and productivity (Eko Nurazizah et al., 2023).

RESEARCH METHOD

This research was conducted at CV. XYZ, Gresik, East Java, in August 2024 until all the necessary data is met. The research used a combination of qualitative and quantitative approaches, with the main method of Waste Assessment Model (WAM), which includes Waste Relationship Matrix (WRM) and Waste Assessment Questionnaire (WAQ) analysis. Primary data was obtained through direct observation of the production process, interviews with relevant parties, and questionnaires to identify waste. Secondary data includes internal company documents and relevant literature. This research focuses on identifying critical wastes in the production process of woven sarongs, which include transportation, inventory, motion, waiting, overproduction, overprocessing, and defects. After identification, a root cause analysis using a Fishbone Diagram was conducted, followed by the preparation of improvement proposals using the 5W1H analysis and the creation of Future State Value

Stream Mapping. This step aims to effectively reduce waste and improve the efficiency of the production process.

RESULTS AND DISCUSSION

Production Process of Woven Sarong

The production process of platinum silver woven sarongs is divided into 3 stages, namely the preparation stage, the weaving stage, and finishing. Each stage consists of several processes. The following is the flow of the woven sarong production process at CV. XYZ.

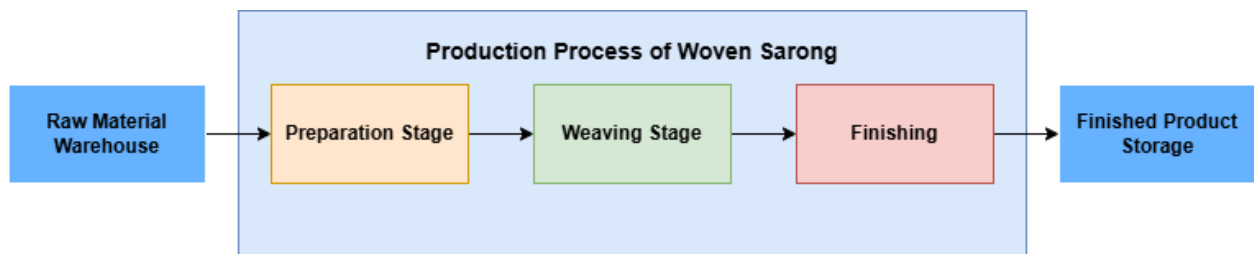


Figure 1
Production Process of Woven Sarong

Current State Mapping

The production process adopts a material flow approach, which generally includes several stages such as preparation, weaving, and finishing. The current state map presents a visual overview of the ongoing production flow, identifying key stages and bottlenecks in the process. This helps to understand inefficiencies as well as areas that require improvement.

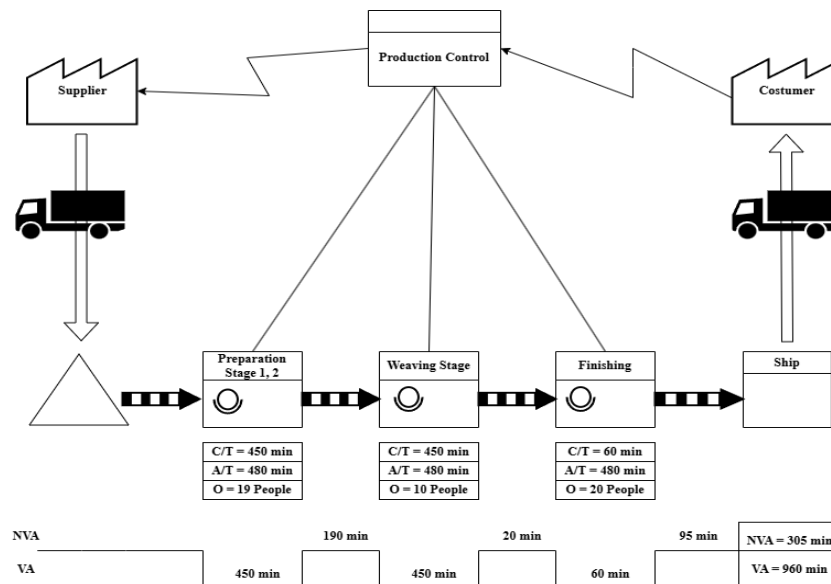


Figure 2
Current State Mapping

Identification Waste

Waste Relationship Value is a matrix that contains letters resulting from the conversion of the average weights in the Waste Relationship Matrix (WRM). The following are the results of the conversion of the average weights of the three respondents presented in matrix form in the table below:

Table 1
Waste Relationship Matrix

F/T	O	I	D	M	T	P	W
O	A	E	I	E	E	X	I
I	O	A	U	A	E	X	X
D	O	I	A	I	E	X	E
M	X	U	I	A	X	A	A
T	U	E	I	A	A	X	A
P	O	O	I	E	X	A	I
W	O	A	U	X	X	X	A

In Table 1, the conversion of numbers to letters is done based on the importance of the relationship, then the letters are converted back into numbers with specific values: A = 10, E = 8, I = 6, O = 4, U = 2, and X = 0. The conversion results are used to calculate the weight of each waste. The following table presents the conversion results in the Waste Matrix Value.

Table 2
Waste Matrix Value Conversion Result

F/T	O	I	D	M	T	P	W	Score	%
O	10	8	6	8	8	0	6	46	17,04%
I	4	10	2	10	8	0	0	34	12,59%
D	4	6	10	6	8	0	8	42	15,56%
M	0	2	6	10	0	10	10	38	14,07%
T	2	8	6	10	10	0	10	46	17,04%
P	4	4	6	8	0	10	6	38	14,07%
W	4	10	2	0	0	0	10	26	9,63%
Score	28	48	38	52	34	20	50	270	100%
%	10,37%	17,78%	14,07%	19,26%	12,59%	7,41%	18,52%	100%	

Based on Table 2, waste transportation and overproduction have the greatest influence in triggering other wastes, with a percentage of 17.04%. The waste to Motion column recorded the highest score of 19.26%, indicating that waste motion is most influenced

by other wastes. From this table, a model of the relationship between wastes in the production process of woven sarongs at CV. XYZ was created, with the total score calculated without including similar relationships (O_O, I_I, D_D, M_M, T_T, P_P, W_W).

Table 3
Final Result of Waste Assessment Questionnaire

	O	I	D	M	T	P	W
Yj (Score)	0,120	0,131	0,101	0,083	0,139	0,047	0,069
Pj Factor	0,018	0,022	0,022	0,027	0,021	0,010	0,018
Yj Final	0,00212	0,00293	0,00222	0,00224	0,00298	0,00049	0,00124
Final Result (%)	14,95%	20,64%	15,59%	15,76%	20,95%	3,42%	8,70%
Ranking	5	2	4	3	1	7	6

Based on Figure Table 3, the highest level of waste in the production of woven sarongs at CV. XYZ is transportation (20.95%), followed by inventory (20.64%), motion (15.76%), delay (15.59%), overproduction (14.95%), waiting (8.7%), and overprocessing (3.42%). Transportation is the most dominant waste, followed by inventory as the next significant waste.

Critical Waste Cause Analysis with Root Cause Analysis

The wastes observed were transportation (20.95%) and inventory (20.64%) as the highest wastes based on the Waste Assessment Model. Root cause analysis was conducted using a fishbone diagram, with data obtained through observation, interview, and information gathering during the research.

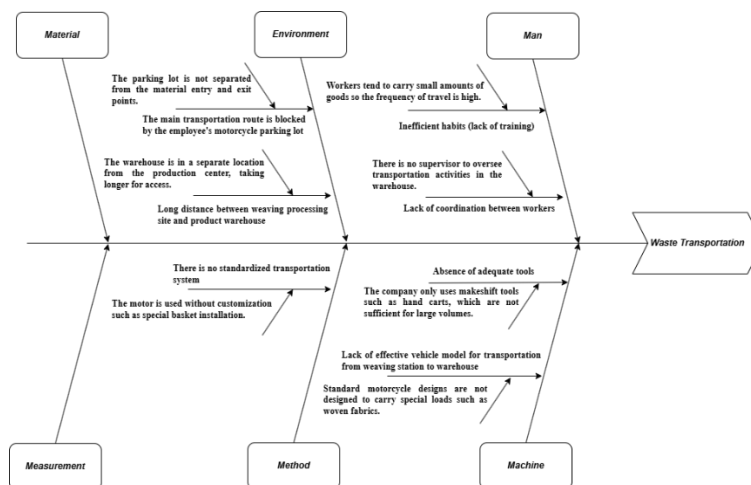


Figure 3
Fishbone Diagram on Waste Transportation

Based on identification using the Waste Assessment Model method, waste transportation is the highest waste in the production of woven sarongs at CV. XYZ. The main problem is ineffective material movement due to the long distance between the weaving processing site and the production warehouse, plus limited space in the warehouse. The narrow area causes queuing, idle time, and material accumulation. The movement path was also obstructed by employees parking their motorcycles near the main access to the warehouse, and narrow aisles slowed down distribution. These constraints reduce production efficiency as time and resources are wasted on non-optimal transportation activities.

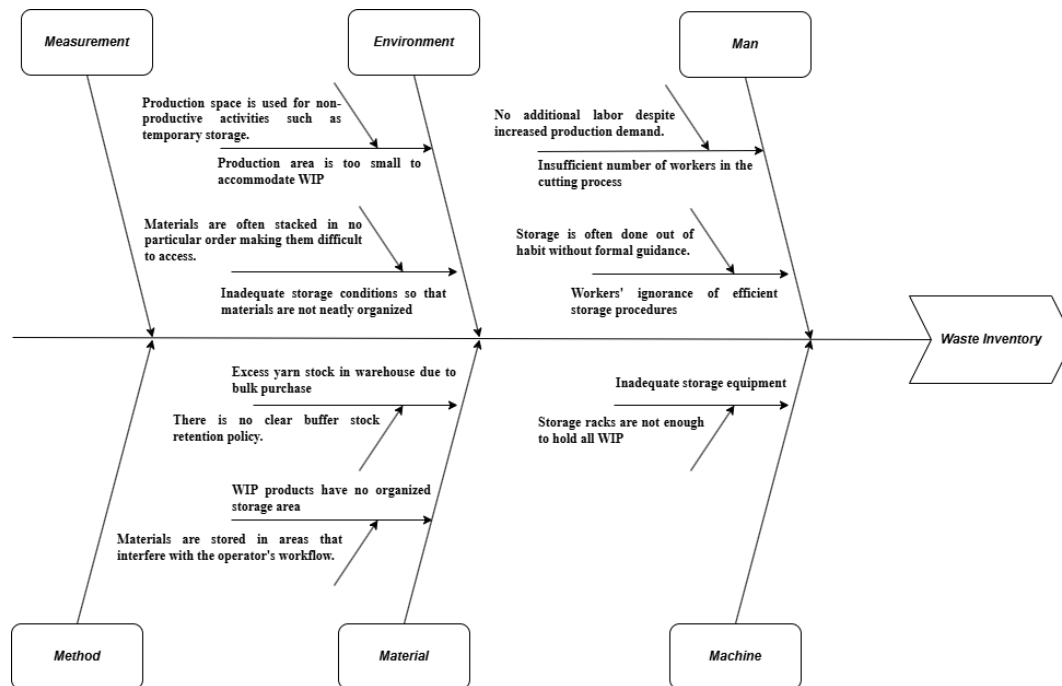


Figure 4
Fishbone Diagram on Waste Inventory

Based on identification with the Waste Assessment Model method, waste inventory is the second largest waste in the production of woven sarongs at CV. XYZ. The main problems include temporary storage of WIP (work in process) products that cause material accumulation in the production area, slow down workflow, and hinder worker access. In addition, overstocking of raw materials in the form of yarn clutters the warehouse, makes stock management difficult, and increases the risk of material damage. These conditions reduce the company's operational efficiency, hinder productivity, and utilize storage space sub-optimally.

Recommended Improvement Alternative

Waste transportation is the most significant waste in the production of woven sarongs at CV. XYZ, with a percentage of 20.95%, is the top priority to improve. After this problem is resolved, the focus is directed to waste inventory to reduce further negative impacts. A 5W+1H analysis based on the fishbone diagram was used to formulate appropriate improvement recommendations, with a table of analysis results compiled as a solution to the waste transportation problem.

Table 4
Alternative Recommendations for Improving Waste Transportation

What	Where	Who	When	Why	How
Inefficient transfer of woven fabric	Weaving Process Station to Cutting Station	Operator	Transferring the woven fabric from the weaving process to the cutting and sewing area	The transportation process is considered an old habit that is not evaluated	Regular evaluation of the transportation process to ensure that the existing facilities and procedures are in line with current production needs. The company should provide modified transportation aids to make moving fabrics easier and faster.
Transportation lanes are too narrow	Woven sarong production warehouse area	Operator	When moving materials and WIP products to the warehouse	The main parking area was designed without taking into account future growth in the number of employees	Rearrange the layout of warehouse areas and transportation routes to optimize existing space, create a policy on the use of motorized vehicles.
Workers tend to carry small amounts of goods so the frequency of travel is high.	Woven sarong production warehouse area	Operator	When moving materials and WIP products to the warehouse	The company has not provided larger or more efficient transportation aids	Provide transportation aids such as large-capacity trolleys or push baskets that can carry more materials in one trip.

Inventory waste is the second highest type of waste in the production of woven sarongs at CV. XYZ, with a percentage of 20.64%. Although slightly lower than waste transportation, it still has a significant impact on production efficiency. After dealing with waste transportation, the next focus is to reduce waste inventory to smooth the production flow. An analysis using the 5W+1H method was conducted to formulate improvement

recommendations based on the root causes of waste inventory. The following is the 5W+1H analysis table for this problem solution:

Table 5
Alternative Recommendations for Improving Waste Inventory

What	Where	Who	When	Why	How
Pileup of semi-finished products (WIP)	Cutting and Sewing Process Area	Operator	During the production process in the Cutting section	Implementation of line balancing is not optimal	Adjust the number of workers or task allocation at each station to achieve balance. Add workers or use automatic cutting machines to reduce waiting time at the cutting stage.
			During the production process of woven sarong	There is no dedicated area for organized WIP storage.	Define and allocate a separate area dedicated to WIP storage with an organized storage system. Companies should use multilevel shelving or vertical systems to maximize the use of storage space without disrupting production flow.
Inefficiently stored materials	Woven sarong warehouse	Operator	During the process of storing materials (raw materials) for woven sarongs	Raw materials are purchased in bulk at once	Provide training to warehouse operators on efficient inventory management, including raw material storage and retrieval techniques. Using methods in determining stock so that it is not excessive such as the use of the EOQ method.

Future State Mapping

The future state map depicts the optimized production process after implementing the suggested improvements. Expected results include reduced waste, increased efficiency, and improved product quality. The map shows smoother material and information flow, shorter lead times, and better alignment between production and demand.

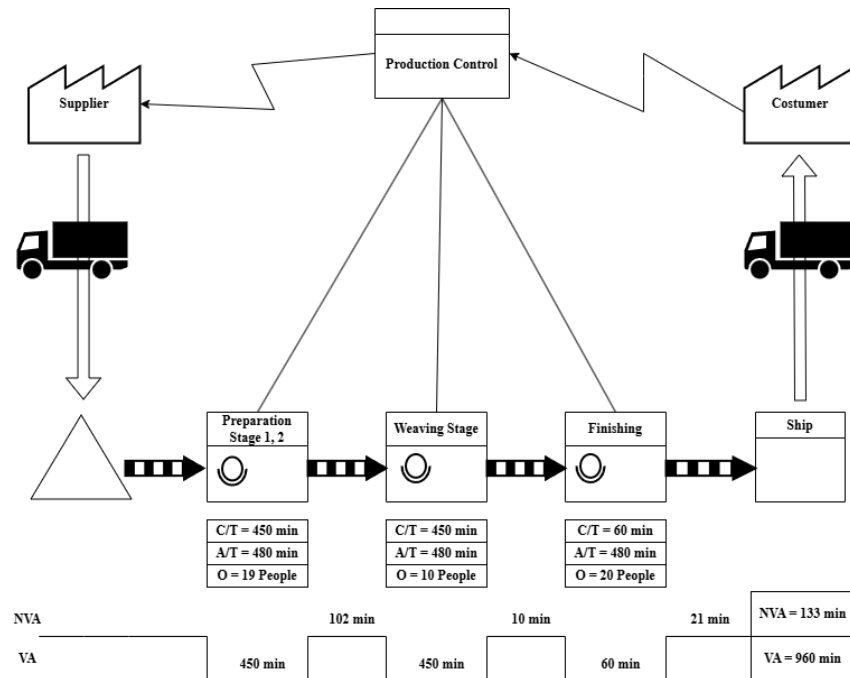


Figure 5
Future State Mapping

Based on the projection of proposed improvements with the help of VSM, the time used for the entire production process of woven sarong is 1265 minutes, then after the projection of proposed improvements, it takes 1093 minutes, meaning that after the proposed improvements the production process time is reduced by 172 minutes or with a percentage of 13.60%.

CONCLUSION

This study successfully identified critical wastes in the production process of woven sarongs at CV. XYZ is using the Lean Manufacturing approach with the WAM method. The results showed two main wastes, namely transportation (20.95%) and inventory (20.64%). Waste transportation occurs due to inefficient fabric transfer, narrow transportation lanes, and high travel frequency. Meanwhile, inventory waste is caused by suboptimal line balancing and WIP accumulation.

Proposed improvements, such as the use of more efficient means of transportation, layout improvements, and inventory management training, are projected to reduce production time by 13.60%, thereby increasing process efficiency.

This research theoretically extends the application of Lean Manufacturing in the traditional textile industry, and practically provides concrete strategies to reduce waste. Future research is recommended to explore more complex waste identification methods and examine the long-term impact of implementing improvements.

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