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Research Article

Waste Analysis Using Value Stream Mapping (Vsm) and Fmea in the Implementation of Lean Manufacturing on the Woven Bag Production Line at PT. Kerta Rajasa Raya

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ABSTRACT

This research aims to analyze and reduce waste in the woven bag production line at PT Kerta Rajasa Raya through the Lean Manufacturing approach using the Value Stream Mapping (VSM) and Failure Mode and Effect Analysis (FMEA) methods. The company experienced various types of waste such as waiting time, unnecessary movement, over-processing, and product defects, which led to a decrease in production efficiency. The analysis results showed that the highest types of waste were unnecessary motion, defects, and excess processing. Using VSM, it was found that of the total production time of 51,997 seconds, only 51.1% were value-added activities. Through the application of FMEA, the main causes of waste were identified based on the highest Risk Priority Number (RPN) value, and a number of improvement recommendations were designed such as improving work layout, implementing quality gate, and strengthening preventive maintenance. After the improvement, production time was reduced to 42,139 seconds and process cycle efficiency increased to 63.1%. These results show that the application of Lean Manufacturing through VSM and FMEA is effective in improving production efficiency and reducing waste in the company.

Keywords: Lean Manufacturing; Value Stream Mapping (VSM); Failure Mode and Effect Analysis (FMEA); Production Efficiency; Waste

1. INTRODUCTION

In the era of globalization and increasingly fierce industrial competition, companies are required to continuously improve production efficiency and effectiveness in order to survive and win the competition. The challenges faced by companies in the manufacturing industry today are cost effectiveness, short lead times, and good product quality (Kurnia & Widyadana, 2022). To win this competition, companies are required to implement the right strategy in order to increase their productivity. One approach that is increasingly popular and proven effective in improving production efficiency is Lean Manufacturing. Lean Manufacturing is a philosophy that focuses on eliminating waste throughout the production process chain, from raw materials to finished products, with the aim of increasing added value for customers. Lean Manufacturing aims to reduce waste by distinguishing between value added and non-value added, focusing on flow, quality improvement and continuous improvement. The use of the Lean Manufacturing concept because it focuses on reducing waste that occurs on the production line. (Dian, et al., 2022).

PT Kerta Rajasa Raya is one of the companies engaged in the production of plastic sacks. The company produces 4 kinds of products namely sewing thread, AD Star cement sacks, woven bags, and jumbo bags with the main products being woven bags and jumbo bags. However, in the woven bag production process, PT Kerta Rajasa Raya faces challenges related to production optimization. Based on the company's data shows that the production defect rate is still a problem that needs to be addressed, with 117,027 defective products recorded from a total production of 14,286,939 woven bags during the period August 2024 to January 2025. In addition to production defects, PT Kerta Rajasa Raya is also faced with various waste problems on the production floor. Some types of waste identified include inefficient waiting time due to delays in production activities. This can be caused by various factors, such as waiting time due to damage to the RTR machine which slows down the printing drying process, In addition, delays in the availability of roll raw materials from the warehouse cause the production line to stop temporarily. Equally significant, unplanned downtime or unexpected disruptions caused the production process to stop for up to one working day or approximately 840 minutes. This caused significant delays and losses in terms of lead time. Furthermore, the waste of unnecessary movement occurred due to some work habits and the irregularity of the support system in the production area. For example, the cutting operator had to look for sandpaper in the warehouse because it was placed too far from the machine, which cut into effective working time. Similarly, sewing operators often had to look for sewing needles and thread them themselves, as they were not directly available in the work area. In addition, in the printing section, time is wasted because operators have to fetch and prepare ink manually, due to the absence of an efficient material preparation system. The total time wasted due to unnecessary movement activities reached 151.6 minutes or about 2 hours and 53 minutes. The company also experienced waste due to unnecessary redundant processes, which is indicated by the high rework rate in the company, which amounted to 41,997 sacks of total products that required rework during the period August 2024 to January 2025. The high rework rate is due to rework on sacks with loose or tenuous stitches, threads that break during the production process must be reattached or replaced with new threads, threads that do not match the size (width or thickness) must be pulled back and reprocessed. This can affect the company's reputation in the market and hinder their business growth in the long run.

Under these conditions, PT Kerta Rajasa Raya needs to strive to improve the efficiency and effectiveness of its production in order to remain competitive. One way to improve production efficiency and effectiveness is by implementing Lean Manufacturing. However, before implementing Lean Manufacturing, the company needs to first understand the condition of the production process flow and identify the waste that occurs in it. For that, a tool or method is needed that can visually map the production process flow and identify the waste that occurs. One of the effective tools for this purpose is Value Stream Mapping (VSM). Value stream mapping is a tool that describes the flow of materials and information in the manufacturing process from upstream to downstream (Baldah, et al., 2021). Value Stream Mapping can be used to reduce the lead time during the production process so that productivity can be increased. The purpose of developing the Value Stream Mapping method is to find out the dependencies between two separate departments and overcome the situation where conventional industrial engineering tools for capturing negative holistics are found (Abdullah, et al., 2024).

Based on the description above, in an effort to identify and minimize waste on the plastic sack production line, a systematic analysis and calculation of each activity in the production process is needed. This includes measuring work time, waiting time, frequency of occurrence of non-productive activities, and process flow mapping using methods such as Value Stream Mapping (VSM) in the application of Lean Manufacturing so as to provide suggestions for improvements that are expected to be the basis for companies to formulate more effective strategies in facing increasingly fierce competition in the plastic sack industry.

2. RESEARCH METHOD

This research was conducted at PT Kerta Rajasa Raya located in Sidoarjo, East Java. This study aims to analyze the waste that occurs in the Woven Bag production line and reduce waste in the woven bag production process. Data collection conducted at PT Kerta Rajasa Raja consists of two types, namely primary data and secondary data. Primary data is data collected directly by researchers in the field during research. Primary data collection is done through three methods, namely interviews, and questionnaires. Secondary data is data obtained by researchers by collecting data that already exists in the company, such as company documents. Data processing is done by going through several stages using the Lean Manufacturing approach, with the Value Stream Mapping (VSM) method. Lean Manufacturing is a philosophy or approach to production that focuses on efficiency and reducing waste, and Value Stream Mapping (VSM) helps identify and eliminate waste in the process.

3. RESULTS AND DISCUSSION

3.1 Woven Bag Production Process Flow

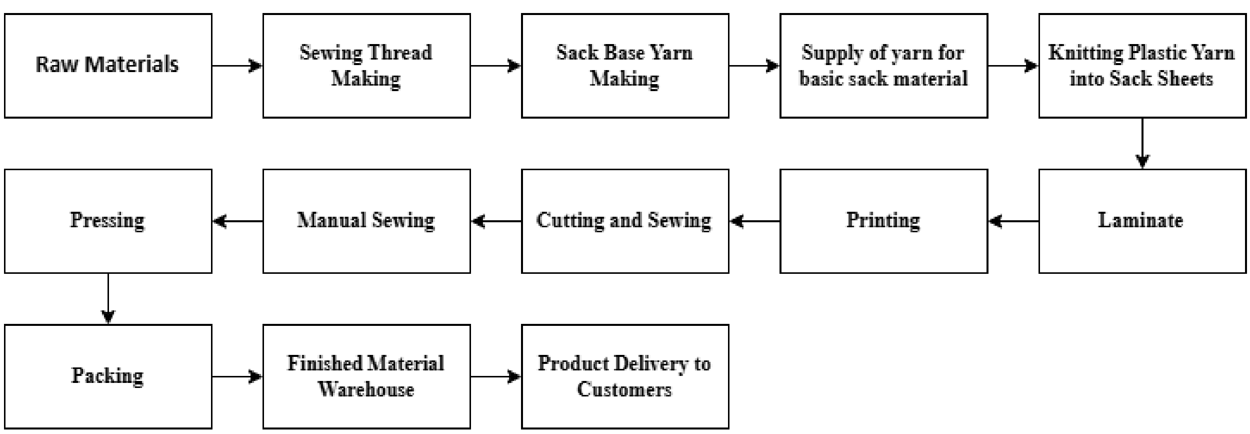

Figure 1. Production Process Flow of Woven Bag PT. Kerta Rajasa Raya

3.2 Production Cycle Time

Cycle time is one of the important indicators used to measure the length of time required to complete one full cycle of an activity or product, from the beginning to the end of the process. Cycle time is the time required to complete a process from start to finish. (Prawiro & Adi, 2021).

Table 1. Production Cycle Time

Process	Activities	Code	Time (seconds)	Total Time (seconds)
Raw Materials	Checking raw materials	A1	600	1.278
	Weighing of raw materials	A2	576	
	Displacement	A3	102	
Sewing Thread Making	Raw Material Inspection	B1	1.848	6.936
	Raw material extrusion process into filaments	B2	2.868	
	Cooling process	B3	732	
	Winding of sewing thread with bobbin	B4	132	
	Cutting Process	B5	468	
	Sewing thread inspection	B6	744	
	Displacement	B7	144	
Sack Base Yarn Making	Raw material melting of sack base yarn	C1	3.186	5.892
	Monitor extrusion temperature and yield	C2	384	
	Film sheet cooling process	C3	732	
	Cutting process into yarn	C4	468	
	Winding of sack base yarn with bobbin	C5	132	
	Inspection of sack bottom yarn yield	C6	798	
	Displacement	C7	192	
Knitting	Basic yarn knitting into sack sheets	D1	4.902	
	Inspection of sack sheets	D2	2.250	
	Displacement	D3	216	
Laminate	Sack sheet lamination process	E1	4.524	7.368
	Inspection of laminated sack sheets	E2	894	
	Displacement	E3	168	
Printing	Retrieve and prepare ink for the printing process	F1	738	5.586
	Sack design printing	F2	4.752	
	Drying the printing	F3	2.322	
	Inspection of printed sheets	F4	708	
	Moving	F5	162	
Cutting and Sewing	Looking for sandpaper for cutting knives	G1	4.224	8.682
	Sack sheet cutting	G2	756	
	Find a sewing needle and install the needle on the sewing cutting machine	G3	2.322	
	Sack stitching	G4	534	
	Inspection of cutting and sewing results	G5	2.376	
	Displacement for re-sewing	G6	1.176	
Manual Sewing	sewing for rework	H1	1.002	
	Displacement	H2	198	
Packing	Finished goods inspection	I1	216	11.388
	finished goods pressing	I2	606	
	Taking labels and packing plastic for the packing process	I3	342	
	packaging of finished goods	I4	486	
	labeling	I5	313	
	transfer to finished goods warehouse	I6	582	
Finished Material Warehouse	Compilation and storage in the warehouse	J1	1.122	

3.3 Current State Value Stream Mapping

The next step is to compile process mapping in the form of Current Value Stream Mapping (CVSM). Current State Value Stream Mapping (C-VSM) consists of a basic mapping of the entire production system and represents all entities and production operators in actuality which is useful for identifying indications of waste along with the source and place of the waste (Syalendra, 2024). This mapping aims to thoroughly describe the current process flow, starting from the entry of raw materials until the finished product is received by consumers. Through this approach, all activities that add value and those that do not can be identified more clearly.

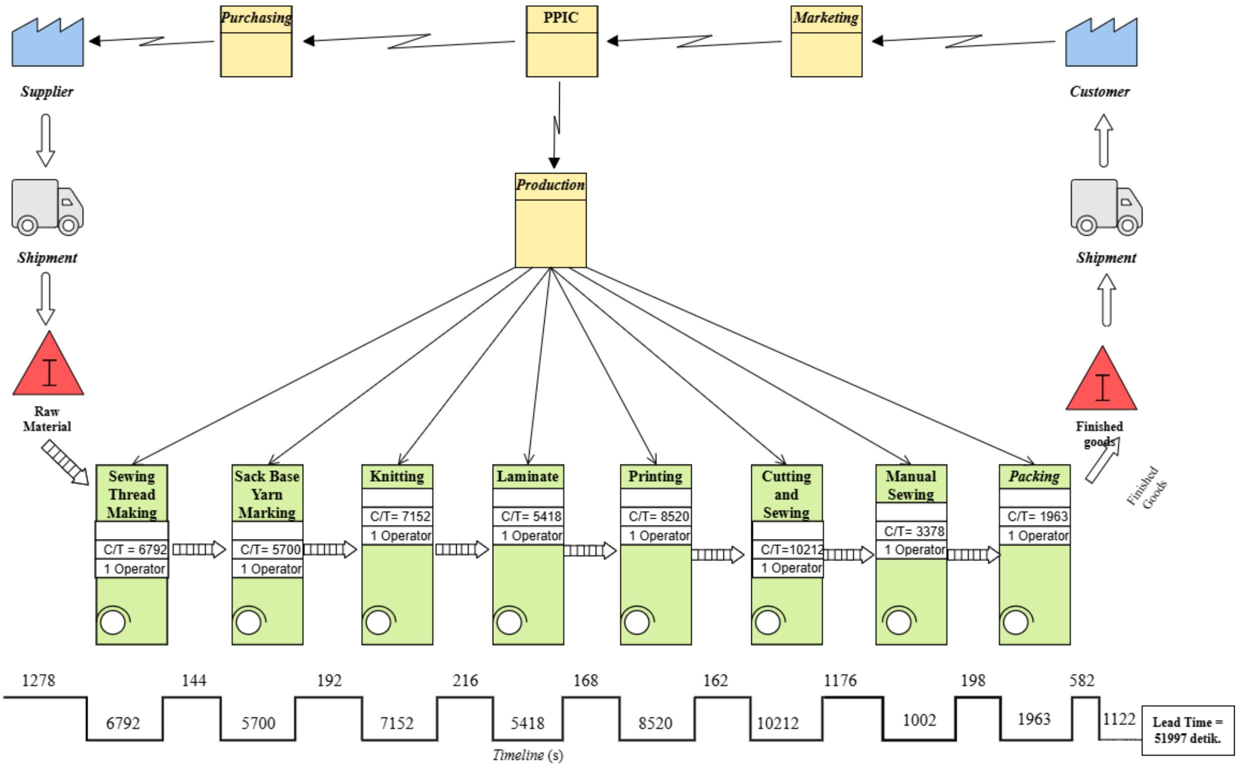

Figure 2. Current Value Stream Mapping

So the time calculation is as follows:

Total Production Time (Lead Time) = 51997 seconds
= 867 minutes 17 seconds
= 14 hours 44 minutes

3.4 Identification of Waste

The questionnaire given to employees was designed with the main purpose of identifying various forms of waste that occur during the production process at PT Kerta Rajasa Raya. After the questionnaires were distributed to respondents, the next step was to process the collected data. The data is then analyzed by calculating the score of each answer to identify the types of waste that occur in the production process.

Table 2. Waste Questionnaire Calculation Results

No.	Type of Waste	Respondents					Average Score	Ranking
		1	**2**	**3**	**4**	**5**		
1	Unnecessary Motion.	4	5	5	5	4	4.6	1
2	Defect	3	4	5	5	3	4	2
3	Excess Process	3	4	4	3	5	3.8	3
4	Waiting (Menunggu)	3	3	3	3	3	3	4
5	Transportation (Perpindahan)	2	2	2	1	2	1.8	5
6	Overproduction (Kelebihan Produksi)	1	2	1	1	1	1.2	6
7	Excess Inventory (Persediaan yang Tidak Perlu)	2	1	1	1	1	1.2	7

3.5 Value Stream Mapping Anlysis Tools (VALSAT)

After calculating the scores obtained from filling out the questionnaire, the next step is to process the data. The average score that has been calculated will be further analyzed using the Value Stream Mapping Analysis Tools (VALSAT). Value Stream Anlysis Tool is an approach used to perform a weighting process on waste. (Saputra, et al., 2023). The application of this method is done by multiplying the predetermined multiplier factor with the results of waste weighting. (Nugroho & Al Faritsy, 2024).

Table 3. VALSAT Score Calculation

Waste	Weight	PAM	SCRM	PVF	QFM	DAM	DPA	PS
Overproduction	1.2	1.2	3.6	-	1.2	3.6	3.6	-
Waiting	3	27	27	3	-	9	9	-
Transportation	1.8	16.2	-	-	-	-	-	1.8
Excess Process	3.8	34.2	-	11.4	3.8	-	3.8	-
Excess Inventory	1.2	3.6	10.8	3.6	-	10.8	3.6	1.2
Unnecessary Motion	4.6	41.4	4.6	-	-	-	-	-
Defect	4	4	-	-	36	-	-	-
Overall Structure	0	0	0	0	0	0	0	0

Based on the results of these calculations, it is found that Process Activity Mapping (PAM) is the most appropriate tool to use in value stream mapping, because it has the highest result value which reflects its effectiveness in identifying activities that do not add value in the process. The function of Process Activity Mapping (PAM) is to identify the added and non-added value of each activity in the production process and to evaluate each activity so that it can run effectively and efficiently(Zulfikar & Rachman, 2020). PAM simplifies the process of identifying activities that occur in a process because there is a classification of activities into five types, namely operations, inspections, delays, transportation and inventory (Suwandi & Suhada, 2024). Each activity involved in the process is grouped based on certain categories such as value-added and non-value-added activities and then the percentage contribution to the overall process is calculated.

Table 4. Total Production Activity

Activities	Frequency	Percentage	Total Time (Seconds)	Percentage
Operation	18	41.9%	27169	52.3%
Transportation	9	20.9%	2940	5.7%
Inspection	9	20.9%	10434	20.1%
Storage	1	2.3%	1122	2.2%
Delay	6	14.0%	10332	19.9%
TOTAL	**43**	**100.0%**	**51997**	**100.0%**
VA	17	39.5%	26593	51.1%
NNVA	11	25.6%	4638	8.9%
NVA	15	34.9%	20766	39.9%
TOTAL	**43**	**100.0%**	**51997**	**100.0%**
PRODUCTION TIME			**51997**	

3.6 Diagram Fishbone

Waste in the production process of PT Kerta Rajasa Raya will be identified what causes and consequences are caused and the production process in order to determine the recommendations for proposed improvements. Fishbone schemes or causality diagrams to determine the effects of process errors that are then taken action to overcome quality problems (Suharto, et al., 2022). The following is an identification of the causes and consequences of waste that occurs in the production process at PT Kerta Rajasa Raya using a cause-and-effect diagram.

1. Types of Waste Unnecessary Motion

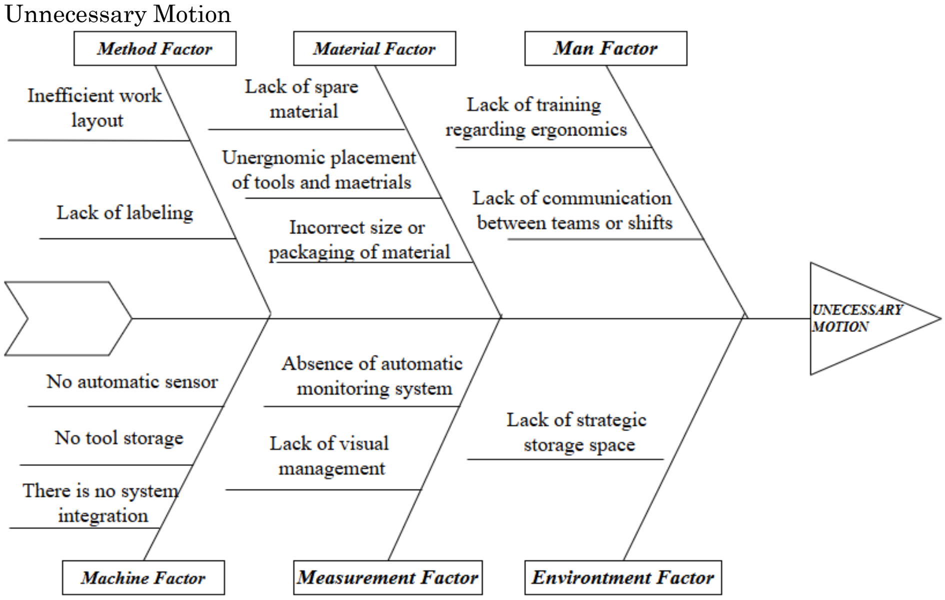

Figure 3. Unecessary Motion Fishbone Diagram

2. Types of Waste Defects

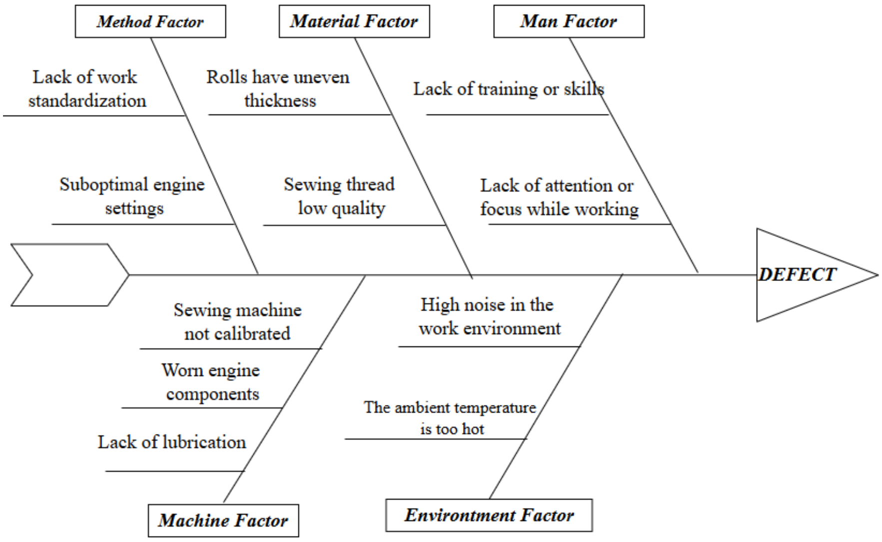

Figure 4. Defect Fishbone Diagram

3. Types of Over-Processing Waste

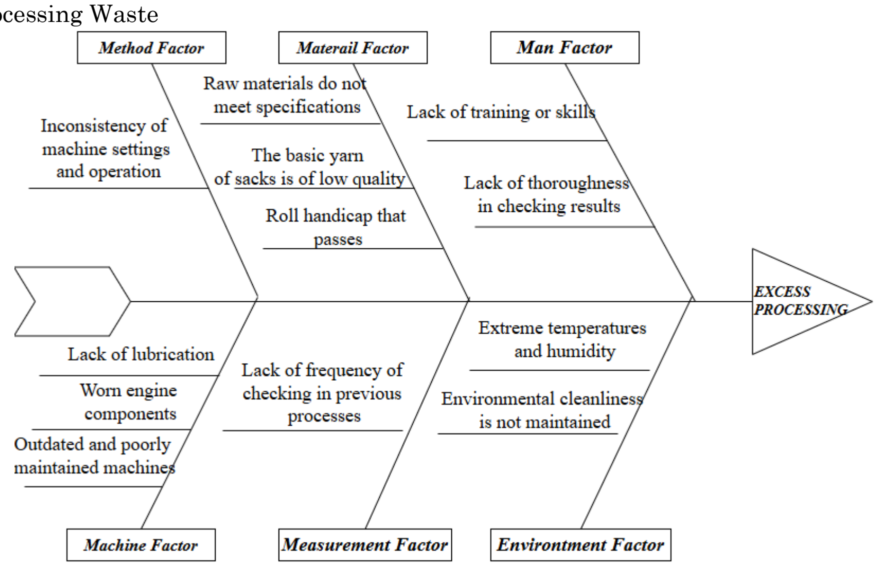

Figure 5. Excess Processing Fishbone Diagram

4. Types of Waste Due to Waiting

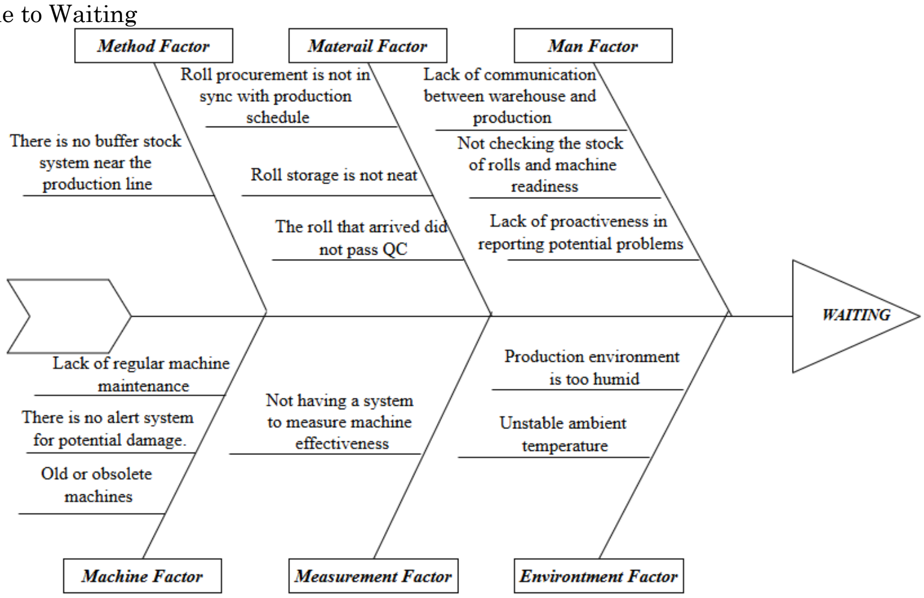

Figure 6. Waiting Fishbone Diagram

3.7 Failure Mode and Effect Analysis (FMEA)

Failure Mode and Effects Analysis (FMEA) is a method used to identify, locate and analyze failures, potential occurrences of a failure, and known problems in a process, system, or service before it reaches the consumer (Farida, et al., 2022). In Failure Mode and Effect Analysis (FMEA) there are several stages in determining the waste that will be handled first, namely setting the boundaries of the process to be analyzed, observing and filling out questionnaires on the analyzed process, the results of the questionnaire are used to find the most influential errors in the production process.

Table 5. Results of the Failure Mode and Effect Analysis (FMEA) Questionnaire Recapitulation

Failure Mode	Potential Filure	Cause oof Failure	Effect of failure	S	O	D	RPN
Unecessary Motion	Addition of activities or movements that are not needed or required	Lack of spare materials	Workers have to make extra effort to retrieve and time-consuming	7	5	5	175
		Unergnomic placement of tools and maetrials		6	8	6	288
		Inefficient work layout		7	8	5	280
Defect	The presence of defects in the form of sacks with holes, sacks with loose stitches, and sewing folds that do not match	Lack of attention or focus while working	Time is wasted on repairing or remanufacturing defective goods which can lower production efficiency	5	4	3	60
		Unsuitable or low-quality materials	Resulting in direct losses as the product has to be discarded or reworked	8	6	4	192
		Non-optimal engine settings	The production process becomes inefficient, requiring rework	7	5	8	280
		Hot and noisy working environment	The stitches are prone to damage during the next process	4	4	3	48
Excess Processing	Rework on defective products	Less thorough in checking results	Added time and extended lead time	6	5	6	180
		Mismatch of machine settings and operation		6	6	8	288
		Defective materials or products that pass inspection		6	7	7	294
Waiting	Waiting for processing or production delays (delay)	Waiting for printing to dry	Accumulated waiting time increases, lead time lengthens, and productivity decreases	6	6	4	144
		Lack of coordination and time management		4	3	4	48
		lack of machine maintenance causes unplanned machine downtime		5	5	8	200
		Limited facilities or tools		5	5	6	150

Proposed improvements from Failure Mode and Effect Analysis (FMEA) are used to identify the types of waste that need to be prioritized for improvement. The largest RPN value is the main cause of the problem at hand. The RPN value is the product of the severity, occurance, and detection values of each cause of the problem (Kartika, et al., 2022). The Risk Number Priority (RPN) calculation is used to make it easier to determine the priority level of the failure mode. (Maulana & Yuamita, 2025).

Table 6. Improvement recommendation data

Failure Mode	Cause oof Failure	RPN	Calculation Level	Improvement Recommendations
Excess Processing	Defective materials or products that pass inspection	294	VERY HIGH	Increase final inspection, use a quality gate system at each stage of production, and implement visual sensors or cameras to automate defect detection.
Unecessary Motion	Unergnomic placement of tools and maetrials	288	VERY HIGH	Redesign the work area so that tools/materials are within ergonomic reach, maximize the application of 5S principles for work area order, and provide flexible shelves and tool holders according to operator work
Excess Processing	Mismatch of machine settings and operation	288	VERY HIGH	Reviewing and standardizing machine working parameters, conducts technical training on operators on a regular basis and implements machine operation SOPs and internal audits.
Unecessary Motion	Inefficient work layout	280	VERY HIGH	Reanalyzed the production layout.
Defect	Non-optimal engine settings	280	VERY HIGH	Schedule regular machine calibrations, use pre-setting adjustment SOPs before production and provide parameter setting sheets for operators.
Waiting	Maintenance causes unplanned machine downtime	200	VERY HIGH	Implement a preventive maintenance system with a regular schedule and provide standby technicians during main production working hours.
Defect	Unsuitable or low quality materials	192	HIGH	Conduct regular supplier audits, implement a strict incoming quality control (IQC) system, and use suppliers with quality certifications.
Excess Processing	Less thorough in checking the results	180	HIGH	Using standard inspection checklists and adding QC training to improve accuracy.
Excess Processing	Lack of spare materials	175	HIGH	Evaluation of spare material requirements based on production frequency.
Waiting	Limited facilities or tools	150	HIGH	Add facilities or tools in the production area and evaluate the need for tools based on work data.
Waiting	Waiting for printing to dry	144	HIGH	Evaluate the drying temperature and time to be more optimal and adjust the dryer capacity to the output of the printing press
Defect	Lack of attention or focus while working	60	MEDIUM	Create a conducive working environment (ventilation, lighting).
Waiting	Lack of coordination and time management	48	LOW	Use visual boards or digital dashboards for scheduling, hold daily briefings to harmonize targets and progress and evaluate the scheduling system to avoid work clashes.

3.8 Future State Value Stream Mapping

Based on the problems that have been identified, activities that do not provide added value and activities that are necessary but do not add value are successfully minimized. Future Value Stream Mapping is a VSM design for the future as a form of improvement of a production line. (Imas, 2022). In this future state VSM, the improvement plan that has been analyzed using the previous fishbone diagram is applied to eliminate activities that are not value-added and are considered wasteful in the current state VSM (Arunizal, et al., 2024).

Table 7. Production Process Time Adjustments

Activities	Process Time Before Improvement (Seconds)	Process Time After Improvement (Seconds)
Raw Material Inspection	1848	0
Monitor extrusion temperature and yield	384	0
Retrieve and prepare ink for the printing process	738	0
Looking for sandpaper for cutting knives	4224	0
Find a sewing needle and install the needle on the sewing cutting machine	2322	0
Taking labels and packing plastic for the packing process	342	0

Description of Improvement:

1. Raw material inspection

In the sewing thread production process, there is a raw material inspection activity that takes 1,848 seconds. However, this activity is considered unnecessary because the inspection of raw materials has actually been carried out in advance by the warehouse at the time of collection.

2. Monitoring temperature and extrusion results

In the basic yarn making stage, there is an activity of monitoring temperature and extrusion results which takes about 384 seconds. This activity is one that does not add value directly and can potentially be eliminated if the monitoring process is replaced with the use of tools in the form of an automatic monitoring system that can work in real-time and consistently without manual involvement.

3. Retrieving and preparing ink for the printing process

At the printing process stage, the time required for retrieving and preparing ink reaches 738 seconds. This time is significant and can be minimized through more efficient management of raw material preparation. One of the efforts that can be made is to record all raw material requirements since production. Thus, materials such as ink can already be prepared completely before the production process begins, so that no additional time is needed to retrieve materials in the middle of the process.

4. Searching for sandpaper for cutting knives

In the cutting and sewing stages, it was found that there was a wasted time of 4,224 seconds spent looking for sandpaper for cutting knives. This activity falls into the non-value-added category and can be eliminated if the arrangement of factory facilities, especially in terms of the placement of production equipment, is done more efficiently.

5. Searching for sewing needles and installing needles on the sewing cutting machine

In the cutting and sewing stages, it was found that there was a wasted time of 2322 seconds spent on sewing needles and installing needles on the sewing cutting machine. This activity is included in the non-value added category and can be eliminated if the arrangement of factory facilities, especially in terms of the placement of production equipment, is carried out more efficiently. One improvement that can be implemented is to ensure that all auxiliary equipment for the manual work process is returned to its original place on the production table after use, thereby reducing search time and improving the smoothness of the production process.

6. Taking labels and packaging plastic for the packing process

In the packing process, there is an activity of taking labels and packaging plastic from the raw material warehouse which takes about 342 seconds. This time is classified as a non-value-added activity and can be eliminated by thoroughly recapitulating the raw material requirements for each production site before the process begins. With this strategy, all supporting materials such as labels and packaging plastics can be ensured to be available from the start, so there is no need for re-taking during the production process.

For more details, the Future Value Stream Mapping of improvements in the production process at PT Kerta Rajasa Raya can be seen in the following figure:

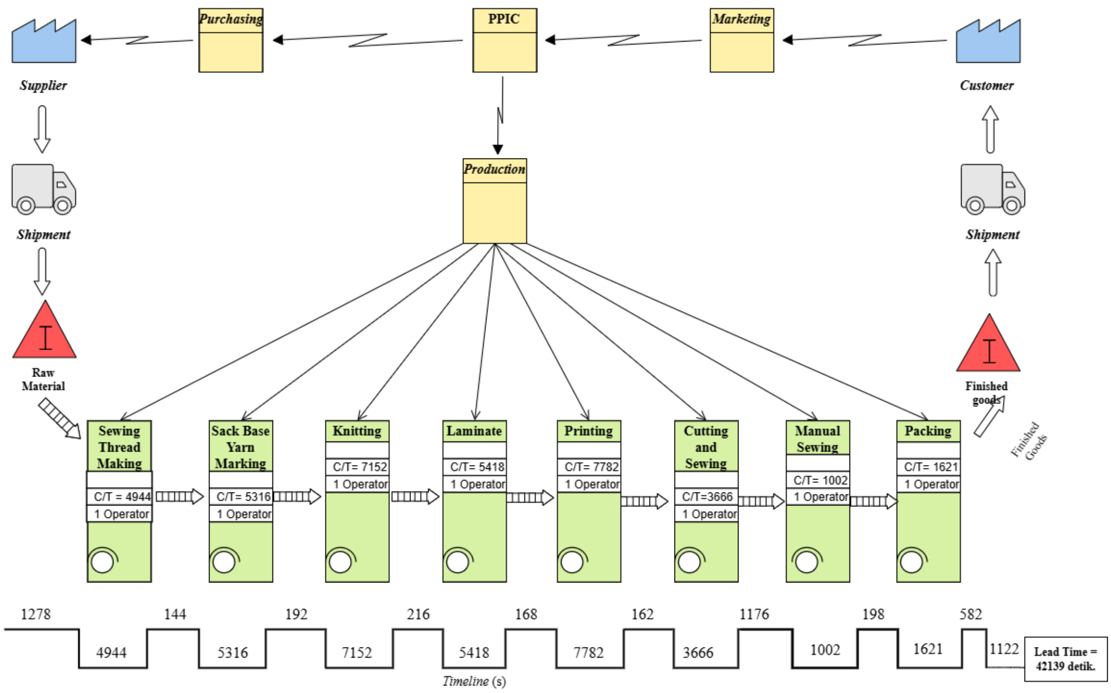

Figure 7. Future Value Stream Mapping Recommendation

The calculation of time after repair is as followst:

a. Total *Value Added* = 26593 seconds
b. Total *Non-Value Added* = 10908 seconds
c. Total *Necessary but Non-Value Added* = 4638 seconds
d. Total Waktu Produksi = 42319 seconds

Table 8. Comparison of Total Production Process Time Before and After

Start Time	Time After Improvement
51997 seconds	42139 seconds
867 minutes 20 seconds	702 minutes 30 seconds
14 hours 44 minutes	12 hour 1 minutes

Table 9. Initial Activity Calculation

Activities	Frequency	Percentage	Total Time (Seconds)	Percentage
Operation	18	41.9%	27169	52.3%
Transportation	9	20.9%	2940	5.7%
Inspection	9	20.9%	10434	20.1%
Storage	1	2.3%	1122	2.2%
Delay	6	14.0%	10332	19.9%
TOTAL	43	100.0%	51997	100.0%
VA	17	39.5%	26593	51.1%
NNVA	11	25.6%	4638	8.9%
NVA	15	34.9%	20766	39.9%
TOTAL	43	100.0%	51997	100.0%
PRODUCTION TIME		51997		

Table 10. Final Activity Calculation

Activities	Frequency	Percentage	Total Time (Seconds)	Percentage
Operation	18	48.6%	27169	64.5%
Transportation	9	24.3%	2940	7.0%
Inspection	9	21.6%	8586	20.4%
Storage	1	2.7%	1122	2.7%
Delay	1	2.7%	2322	5.5%

Activities	Frequency	Percentage	Total Time (Seconds)	Percentage
TOTAL	**37**	**100.0%**	**42139**	**100.0%**
VA	17	45.9%	26593	63.1%
NNVA	11	29.7%	4638	11.0%
NVA	9	24.3%	10908	25.9%
TOTAL	**37**	**100.0%**	**42139**	**100.0%**
WAKTU PRODUKSI			**42139**	

Table 11. Comparison of Process Cycle Efficiency (PCE) Before and After

Initial Process Cycle Efficiency (PCE)
Process Cycle Eficiency (PCE) = $\frac{value\ added}{\text{Cycle Time}}$ x 100% = $\frac{26.593}{51.9997}$ x 100% = 51,1 %
Process Cycle Efficiency (PCE) After Improvement
Process Cycle Eficiency (PCE) = $\frac{value\ added}{\text{Cycle Time}}$ x 100% = $\frac{26.593}{42.139}$ x 100% = 63,1 %

4. CONCLUSION

This study shows that the application of Lean Manufacturing with Value Stream Mapping (VSM) and Failure Mode and Effect Analysis (FMEA) approaches can effectively identify and reduce various types of waste in the woven bag production process at PT Kerta Rajasa Raya. The most dominant types of waste are unnecessary motion, defects, and excess processing, which significantly affect the efficiency and effectiveness of the production process. By utilizing VSM, it is known that only 51.1% of the total production time actually provides added value. After improvements were made based on FMEA analysis, there was an increase in production time efficiency, with total time reduced from 51,997 seconds to 42,139 seconds and process cycle efficiency increased to 63.1%. Therefore, the use of VSM and FMEA methods not only helps identify the root causes of waste, but also provides strategic direction in decision-making to improve the company's overall operational performance.

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