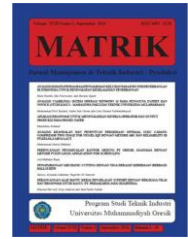




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Analysis of Production Process Waste Using Lean Manufacturing Approach at PT. XYZ

Nur Muafiatul Farichah^{1*}, Wiwin Widiasih²

^{1,2}Department of Industrial Engineering, Faculty of Engineering, Universitas 17 Agustus 1945 Surabaya

Jl. Semolowaru No. 45 Surabaya, 60118, East Java, Indonesia

Email : 1412200075@surel.untag-sby.ac.id

*Corresponding Author

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ABSTRACT

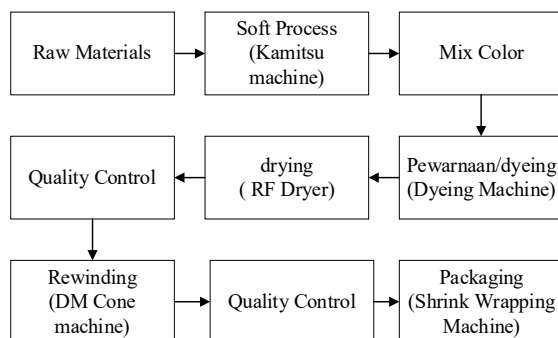
Waste in the production process can reduce efficiency and hinder the smooth flow of production. This study aims to identify the types of waste, analyze the causes of waste, and provide improvement suggestions using the Lean Manufacturing approach in the production process at PT XYZ. The methods used include Value Stream Mapping (VSM) to map the production flow, Process Activity Mapping (PAM) to identify value-added (VA), non-value-added (NVA), and necessary non-value-added (NNVA) activities, as well as Root Cause Analysis (RCA) to determine the root causes of waste. The research results show that the dominant wastes are waiting, inventory, and motion. Improvement proposals were made through Future State Mapping (FSM) with layout improvements, preventive maintenance, and work in process (WIP) control. The improvement results show a reduction in processing time, a decrease in transfer distance, and an increase in production flow efficiency.



1. Introduction

The competition in the manufacturing industry encourages companies to improve the efficiency of their production processes in order to meet market demands, maintain product quality, and enhance the operational performance of the company [1]. Production is an activity that transforms various inputs into outputs, so effective and efficient process management is necessary to create added value [2]. The textile industry, as one of the developing manufacturing sectors, is also required to manage the flow of production optimally so that production activities can run smoothly and minimize waste [3].

PT XYZ is a manufacturing company in the textile sector that produces various types of yarn for both local and export markets. In its production process, the company uses raw materials such as nylon and rayon, which are processed through several production stages as follows.



Picture 1. Production Process Flow

In its operations, potential waste such as waiting, inventory, and motion are still found [4]. This is based on field observations and interviews with workers, caused by several issues such as waiting activities between processes, frequent machine downtime during the rewinding process, non-value-added activities by operators such as moving back and forth between machines, and product rework waste at the rewinding and soft processing workstations. In addition, there is an imbalance in capacity between processes that causes a buildup of work in process (WIP) after the dyeing and drying processes, before rewinding or pre-winding, and hinders the smooth flow of the production process. These conditions can

reduce the efficiency of the production process, so waste identification is necessary.

This research uses the Lean Manufacturing approach, specifically the Value Stream Mapping (VSM) method, VALSAT with Process Activity Mapping (PAM) tools, and Root Cause Analysis (RCA) to identify and minimize waste in the production process. Lean Manufacturing is a systematic approach to identifying, reducing, and eliminating waste through continuous improvement to enhance efficiency and value addition in the production process [5]. As for the methods, there is Value Stream Mapping (VSM) used to map the flow of materials and information, then Process Activity Mapping (PAM), which is part of the VALSAT tools used to identify value-added, non-value-added, and necessary non-value-added activities, while Root Cause Analysis (RCA) is used to determine the root causes of the waste that occurs [6].

The selection of the method is based on previous research that shows that the combination of VSM, PAM, and RCA methods is effective in identifying dominant wastes such as waiting, inventory, and motion, and provides improvement proposals that can enhance production process efficiency [7]. In addition, the method is considered suitable for the characteristics of the problems in the yarn production process because it can identify non-value-adding activities and help formulate process improvements in a more targeted manner [8].

2. Research Methods

The research method was conducted systematically to identify and minimize waste in the production process using the Lean Manufacturing approach. This research was conducted at PT XYZ on the production process of Tritop sewing thread, with a focus on identifying waste that affects the efficiency of the production process. The Lean Manufacturing approach was applied using Value Stream Mapping (VSM), Process Activity Mapping (PAM), and Root Cause Analysis (RCA) methods to analyze the

production process conditions and formulate improvement proposals.

Data collection was carried out through observation, interviews, documentation, and measurement of production process time. The data used consists of primary and secondary data related to production activities. Primary data is obtained through direct observation of the production process and interviews with company representatives, while secondary data is obtained from company documents that support the research. The data collected is then processed through the calculation of production process activity times, followed by data uniformity tests and data sufficiency tests to ensure that the data used meets the processing requirements.

The processing and analysis stage is carried out using Value Stream Mapping (VSM) to map the flow of materials and information in the production process, Process Activity Mapping (PAM) to identify value-added and non-value-added activities, and Root Cause Analysis (RCA) to determine the root causes of waste as a basis for formulating improvement proposals. Subsequently, Future State Mapping (FSM) is prepared to illustrate the condition of the production process after the implementation of the improvement proposals.

3. Results and Discussions

Uniformity test of data

The uniformity test is conducted to ensure that the observation data is in a stable condition. Data is declared uniform if all data points fall within the upper control limit (UCL) and the lower control limit (LCL). Based on the test results, all data points are within control limits, so the data is declared uniform and suitable for further analysis. Below is an example of UCL and LCL calculations from a soft process.

$$UCL = \bar{X} + k \sigma = 250.6 + 3 (0.12) = 250.96$$

$$LCL = \bar{X} - k \sigma = 250.6 - 3 (0.12) = 250.24$$

The following table shows that the data from the entire process has been uniform and can proceed to the next stage.

Table 1. Uniformity test of data

No	Workstation	$\bar{X}$ (menit)	UCL (menit)	LCL (menit)	Status
1	Soft Process	250.6	250.96	250.24	Uniform
2	Color Mixing	83.9	84.26	83.54	Uniform
3	Dyeing	497	497.36	496.64	Uniform
4	Drying	49.8	50.16	49.44	Uniform
5	Quality Control	29.6	29.96	29.24	Uniform
6	Winding	50.3	50.66	49.94	Uniform
7	Packing	16	16.36	15.64	Uniform

Data Sufficiency Test

Next, the adequacy test results show that the actual number of observations (N) of 30 is greater than the minimum number of observations (N'), as can be seen in the table below.

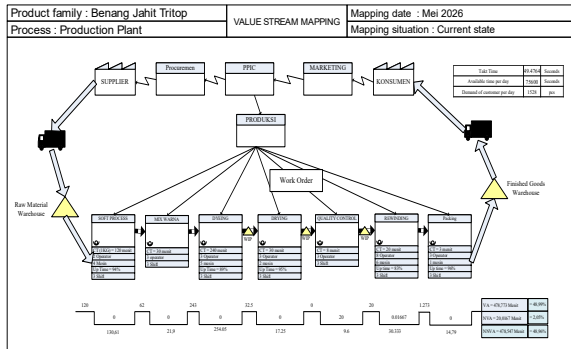
Table 2. Data Sufficiency Test

No	Stasiun Kerja	$\bar{x}$	N	N'	Status
1	Soft Process	250.6	30	1	Enough
2	Mixing	83.9	30	1	Enough
3	Dyeing	497	30	1	Enough
4	Drying	49.8	30	1	Enough
5	Quality Control	29.6	30	1	Enough
6	Winding	50.3	30	1	Enough
7	Packing	16	30	1	Enough

From the data sufficiency test above, the data is deemed sufficient for use in VSM and PAM analysis.

Current State Mapping

Current State Mapping describes the actual condition of the current production process flow, including activities, information flow, and process time [9]. The initial stage of creating the current state mapping is the collection of data on cycle time, lead time, uptime, number of machines, and number of operators [10]. From the data processing, a Current State mapping was created as shown in the image below.



Picture 2. Current State Mapping

Procces Activity Mapping

Process Activity Mapping (PAM) is used to map all activities in the yarn production process at each workstation by categorizing activities into operation, transportation, inspection, delay, and storage to identify value-added and non-value-added activities [11]. The mapping results indicate that there are still activities that have the potential to cause waste, so improvement efforts are needed to enhance the efficiency of the production process. The PAM results for all workstations can be seen in the table below.

Table 3. Procces Activity Mapping Soft Procces

Activity	Total	Time (Minute)	Percentage (%)
Operation	1	120	48%
Transportation	5	10.25033	4%
Inspection	1	0.25	0.10%
Storage	2	0.117	0.05%
Delay	1	120	48%
Total	10	250.61733	100
VA	1	120	48%
NVA	0	0	0%
NNVA	9	130.61733	52%
Total	10	250.61733	100

The table above is the PAM calculation for one of the workstations, namely the Soft Process. Below is a series of calculations for all workstations.

Table 4. Overall Classification of PAM Workstation

Work station	Type of Activity (Quantity)					Classification (Time)		
	O	T	I	D	S	VA	NVA	NNVA
Soft Process	1	5	1	1	2	120	0	130.6
Color Mixing	5	3	4	1	1	62	0	21.9
Dyeing	5	4	1	1	1	243	0	254.0
Drying	5	2	0	0	0	32.5	0	17.3
Quality Control	1	1	3	1	0	0	20	9.6
Winding	1	5	3	1	2	20	0	30.3
Packing	4	3	2	0	0	1.3	0	14.7
TOTAL	22	23	14	5	6	478.7	20.0	478.4

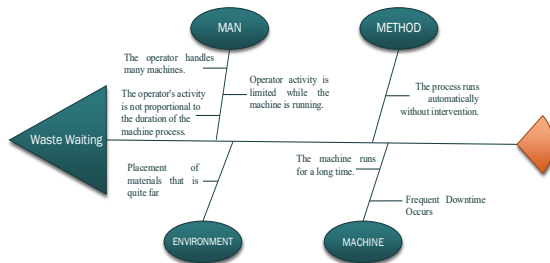
Based on Table 2, the Quality Control station has the lowest VA percentage at 0%, followed by the packing station at approximately 8% and the winding station at approximately 40%. This condition indicates that several activities in the production process do not directly add value. Waiting waste was identified at the soft process and dyeing stations due to process waiting times and machine downtime. Inventory waste was found at the drying station due to the accumulation of work in process (WIP) between production processes. Meanwhile, motion waste was identified at the soft process, winding, and packing stations due to excessive operator and material movements caused by the suboptimal facility layout. These conditions reduce production flow efficiency and may increase the overall processing time.

Root Cause Analysis

Root Cause Analysis (RCA) is conducted to identify the root causes of waste in the production process [12]. Root Cause Analysis (RCA) was conducted on three dominant types of waste using a fishbone diagram to identify the root causes of the problems occurring in the production process. The analysis was conducted on waiting waste, inventory waste, and motion waste by considering human factors (man), machine (machine), method (method), material (material), and work environment (environment). Through this analysis, the factors causing waste that affect the efficiency of the production process were identified, which can be used as a basis for formulating

improvement proposals. The following are the results of identifying the root causes of the problem based on the fishbone diagram analysis.

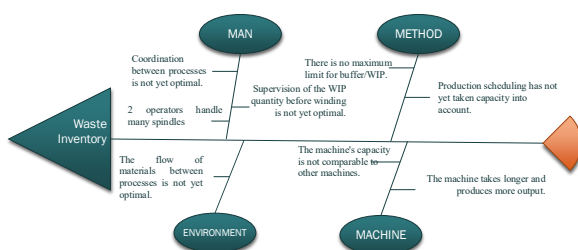
1. Waste Waiting (Soft Process & Dyeing):



Picture 3. Fishbone Diagram Waste Waiting

From the fishbone diagram above, waste is caused by the imbalance between operator working time and machine operating time, resulting in waiting time during the production process. Additionally, the absence of standard work and the arrangement of parallel work activities result in a less than optimal process flow. Another factor that affects it is machine downtime, which hinders the smoothness of production. At the dyeing station, the suboptimal grouping of color batches causes the machine's capacity to be underutilized, potentially increasing waiting times and reducing production process efficiency. This condition disrupts the production flow and creates waiting waste in the production process.

2. Waste Inventory (Drying & Winding):

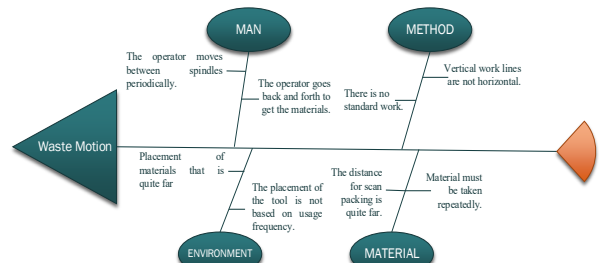


Picture 4. Fishbone Diagram Waste Inventory

It occurs due to the imbalance of capacity between workstations, where the dyeing process produces 100 pcs per batch, while drying can only accommodate 50 pcs per cycle. A similar condition also occurs in the pre-winding area when the drying output exceeds the winding capacity. Additionally, the absence

of a maximum WIP limit and production scheduling that does not take machine capacity into account leads to inventory waste and material accumulation between processes.

3. Waste Motion (Winding & Packing):



Picture 5. Fishbone Diagram Waste Motion

Due to the suboptimal layout of the work area, the less integrated placement of facilities, and the absence of standard work related to operator movements. At the packing station, the position of the packing scan area, which is 39 meters away from the packing area, causes operators to make back-and-forth movements that do not add value, resulting in waste motion and reducing production process efficiency.

Proposal for Improvement

Based on the results of waste identification and Root Cause Analysis (RCA), three groups of improvement proposals were formulated to minimize waste occurring in the production process.

1. Waste Inventory

To control the waste inventory, we can set a maximum WIP limit in the dyeing-drying and drying-winding buffer areas, monitor WIP periodically, and implement

[illegible]

Picture 7. Visual Control Board

visual control and a pull system to reduce material accumulation. Below are the

proposed visual control implementations in the areas with accumulation.

The visual control board functions to monitor the amount of WIP and the flow of materials visually, making it easier to identify bottlenecks and control the production process.

2. Waste Waiting

The proposed improvements to reduce waiting time waste are carried out by regulating the process flow more evenly between workstations, controlling material queues, and reducing machine downtime through the implementation of preventive maintenance and machine inspections before operation. In addition, periodic monitoring of Work In Process (WIP) is conducted to prevent accumulation and smooth the flow of production.

The implementation of these improvements is also supported by optimizing the quality inspection process through adjustments to the inspection flow to make it more integrated with the production process, as well as the use of a visual checklist to speed up the inspection process and reduce waiting time during the inspection stage. Thus, the proposed improvements are expected to minimize non-value-added waiting activities and enhance the overall efficiency of the production flow.

3. Waste Motion

The proposal to improve waste motion is carried out by minimizing non-value-added operator movements through the reorganization of the work facility layout and changes in the workflow to reduce movement distance and travel time. Improvements are applied to the soft process, winding, and packing workstations, which are indicated to experience waste motion, with the expectation of increasing work movement efficiency and

smoothing the flow of the production process. The initial layout of all workstations can be seen in the following image [13]



Picture 8. Layout Before Repair

Soft Process and Winding Work Area

Changes were made to the layout of the work facility by moving the position of the material basket and scale, which were previously located beside the machine, to the center between the two machines. Additionally, the operator's workflow was changed from vertical to horizontal to shorten the transfer during the production process. This change aims to reduce the operator's transfer distance, facilitate access to materials and work equipment, and reduce non-value-adding activities (waste motion). Here are the calculations for the basket and scale.

1. Yarn Basket

Given :

Width between machines	= 2,5 meters
Meters width of the basket	= 0,43 meters
Length of the basket	= 0,60 meters

Because the basket is placed between two machines, the part used to calculate the remaining space is the width of the basket, which is 0.43 m. With the following calculation.

$$2,5 - 0,43 = 2,07 \text{ meter}$$

Because the basket is placed in the middle, the empty space on the right and left sides of the basket is:

$$\frac{2,07}{2} = 1,035 \text{ meter}$$

So, if the basket is placed in the middle between the machines with a distance of 2.5 meters between the machines, there will still be

about 1.035 meters of space available on the right and left sides of the basket.

2. Scale

Given :

Length = 0,165 meters

Width = 0,25 meters

Width between machines = 2,5 meters

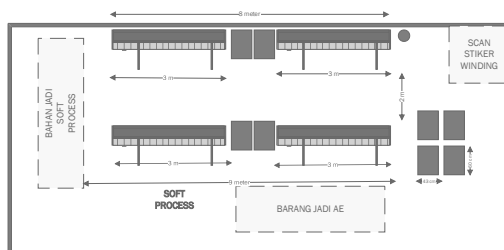
Because the scale is placed between two machines, the part used to calculate the remaining space is the width of the scale, which is 0.25 m. With the following calculation.

$$2,5 - 0,25 = 2,25 \text{ meter}$$

Because the scale is placed in the middle, the empty space on the right and left sides of the basket is:

$$\frac{2,25}{2} = 1,125 \text{ meter}$$

So, if the scale is placed in the middle between the machines with a distance of 2.5 meters between the machines, there will still be about 1.125 meters of space available on the right and left sides of the scale.



Picture 9. Soft Process Layout Before Improvement

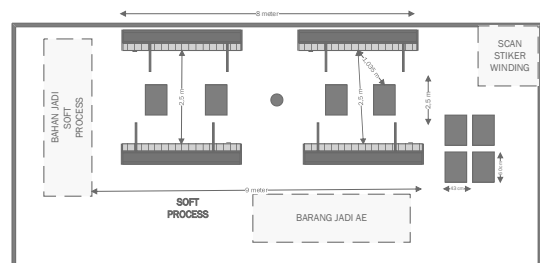
Based on the initial layout of the soft process work station, the operator's movements are still quite long, with a distance of 3.6 meters from the thread pickup to the machine, 3 meters from the chest pickup to the machine, 8 meters for monitoring between spindles, 4 meters for the weighing process, and 4 meters for moving the soft product basket to the soft product rack. These conditions cause the operator's movements to increase, potentially leading to waste motion and reducing the efficiency of the production process.

Table 5. Distance of the Soft Process Workstation Before Improvement

Stasiun Kerja : Soft Proses		
-----------------------------	--	--

From	To	Distance (m)
Thread pickup in the basket	Machine	3.6
Taking the chest in the basket	Machine	3
Monitoring the right spindle	Spindel left	8
Machine	Scale	4
Scale	Soft result basket	3
Soft result basket	Soft result rack	4

The improvement results show that the distance of the right spindle monitoring to the left spindle has decreased from 3 meters to 2.5 meters, while the distance from the machine to the soft output basket has become 1.035 meters. This change helps improve workflow efficiency and minimize waste motion.



Picture 10. Layout Soft Process After Improvement

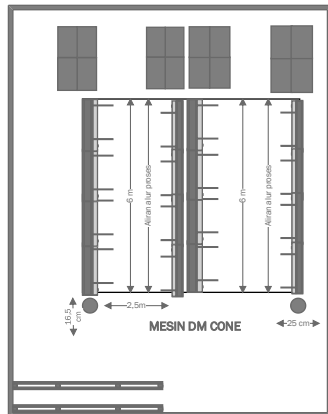
Table 6. Distance of the Soft Process Workstation After Improvement

Stasiun Kerja : Soft Proses		
From	To	Distance (m)
Thread pickup in the basket	Machine	3.6
Taking the chest in the basket	Machine	3
Monitoring the right spindle	Spindel left	2,5
Machine	Scale	2,5
Scale	Soft result basket	1,9
Soft result basket	Soft result rack	4

The change also occurred at the Winding workstation because there are materials that require excessive movement. Below is an initial layout of the Winding workstation.

Based on the winding workstation layout, the operator's movement is still quite high with a thread pickup distance to the machine of 3.9 meters, a chest pickup distance to the machine of 3.5 meters, spindle monitoring reaching 6 meters, a scale pickup distance of 3 meters, and

a production result transfer distance to the result rack of 4 meters.



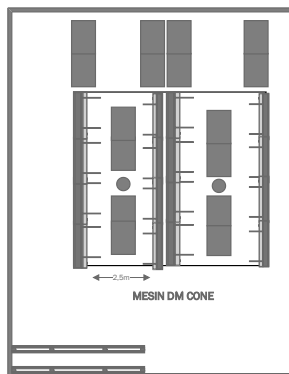
Picture 11. Winding Layout Before Improvement

These conditions cause the operator's movements to increase, potentially leading to waste motion at the winding workstation.

Table 7. Distance of the Winding Workstation Before Improvement

Stasiun Kerja : Winding		
From	To	Distance (m)
Taking thread from the basket	Machine	3.1
Taking the chest in the basket	Machine	3.2
Monitoring the right spindle	Spindel left	6
Scale	Machine	3
Temporary storage of the machine	shelf result	4

The improvement results show that the distance from the raw material basket to the machine has become 1.035 meters, making the workflow more efficient, reducing unnecessary movements, and helping to minimize waste motion in the winding area.

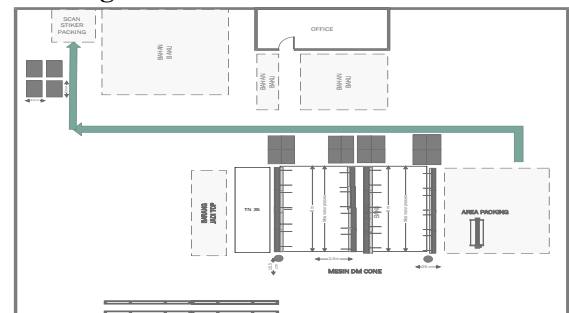


Picture 12. Winding Layout Before Improvement

Table 8. Distance of the Winding Workstation After Improvement

Stasiun Kerja : Winding		
From	To	Distance (m)
Taking thread from the basket	Machine	1,035
Taking the chest in the basket	Machine	1,035
Monitoring the right spindle	Spindel left	6
Scale	Machine	1,125
Temporary storage of the machine	shelf result	4

Packing Work Area



Picture 13. Packing Layout Before Improvement

In the initial layout of the packing work station, there is waste motion due to the distance between the packing scan area and the packing area, which reaches 39 meters, causing excessive operator movement and reducing production process efficiency.

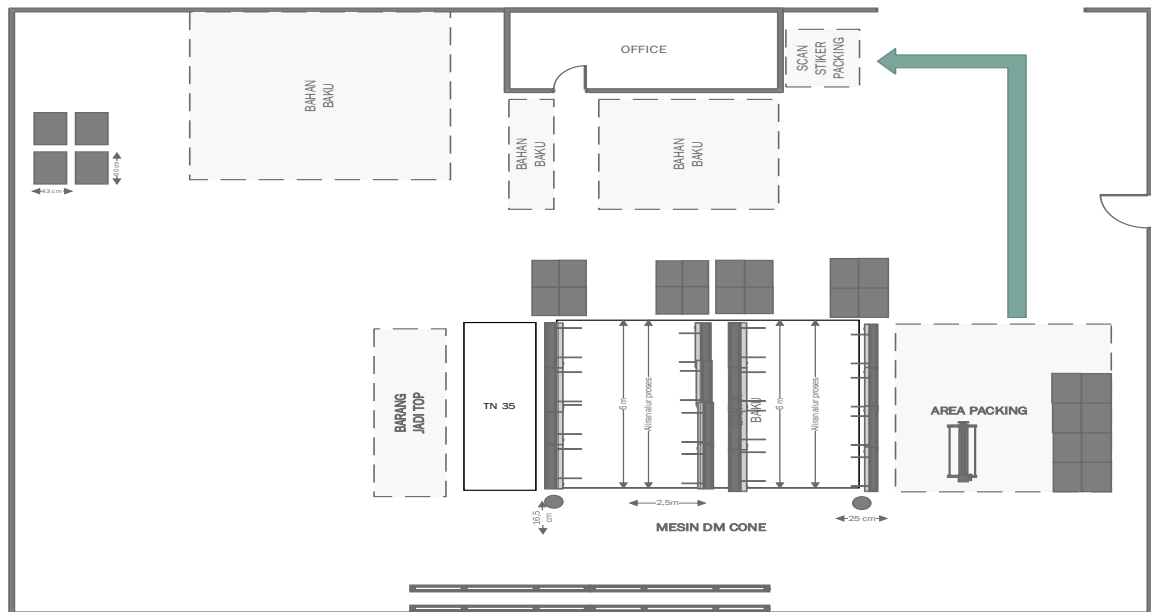
Table 9. Distance of the Packing Workstation Before Improvement

Workstation : Packing		
From	To	Distance (m)
Packing	Scan Packing	39

The previous placement of the scan packing was near the raw material area to accommodate supporting installations and space availability. However, this location limited the operators' movement and made the workflow less efficient. Therefore, a proposal was made to relocate the scan packing area closer to the office to facilitate operator movement, improve the tidiness of the work area, and support the supervision of the production process.

In the proposed layout, the packing scan position is moved to the front office area,

reducing the operator's movement distance to 13 meters.



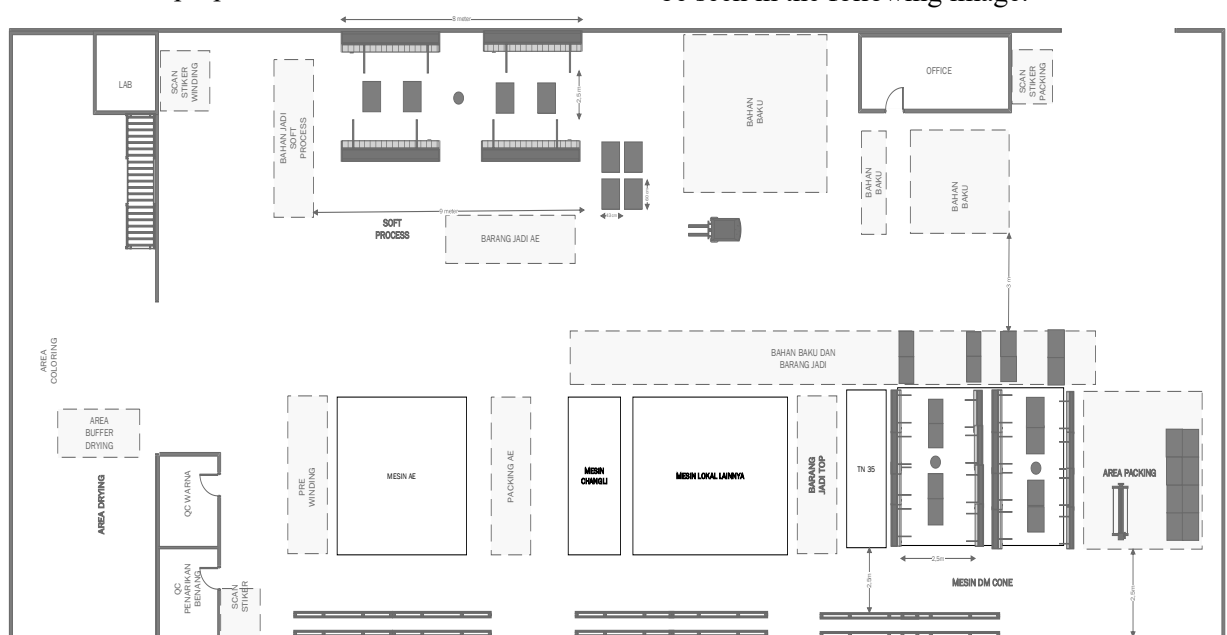
Picture 14. Packing Layout After Improvement

Table 10. Distance of the Packing Workstation Before Improvement

Workstation : Packing		
From	To	Distance (m)
Packing	Scan Packing	13

This change helps reduce waste motion, shorten the workflow, and improve the efficiency of the packing process. From several proposed relocations at the three

workstations, overall improvements have been made to the production facility layout to reduce the distance between activities, minimize non-value-added movements, and balance the flow of the production process. Thus, the proposed layout condition becomes more efficient compared to the initial condition and can support overall productivity improvement. A complete overview of the improved layout can be seen in the following image.



Picture 6. Layout After Repair

Changes After Improvements

After the improvements were made, there were changes in the time and distance of movement in several processes, making them shorter compared to the previous conditions due to the elimination and merging of several work elements. The estimated time changes after the improvements are as shown in the following table.

Table 11. PAM Classification After Improvement

Work station	Type of Activity (Quantity)					Classification (Time)		
	O	T	I	D	S	VA	NVA	NNVA
Soft Process	1	5	1	1	2	120.0	0.0	130.5
Color Mixing	5	3	4	1	1	62.0	0.0	21.9
Dyeing	5	4	1	1	1	243.0	0.0	254.0
Drying	5	2	0	0	0	32.5	0.0	17.3
Quality Control	1	1	3	1	0	0.0	20.0	9.6
Winding	1	5	3	1	1	20.0	0.0	30.3
Packing	4	3	2	0	0	1.2	0.0	14.1
TOTAL	22	23	14	5	5	478.7	20.0	477.7

After the layout and process flow improvements were made, there were changes in the transfer distances for several work activities, resulting in shorter and more efficient operator movements. A comparison of the transfer distances before and after the proposed improvements can be seen in the table below.

Table 12. Distance After Repair

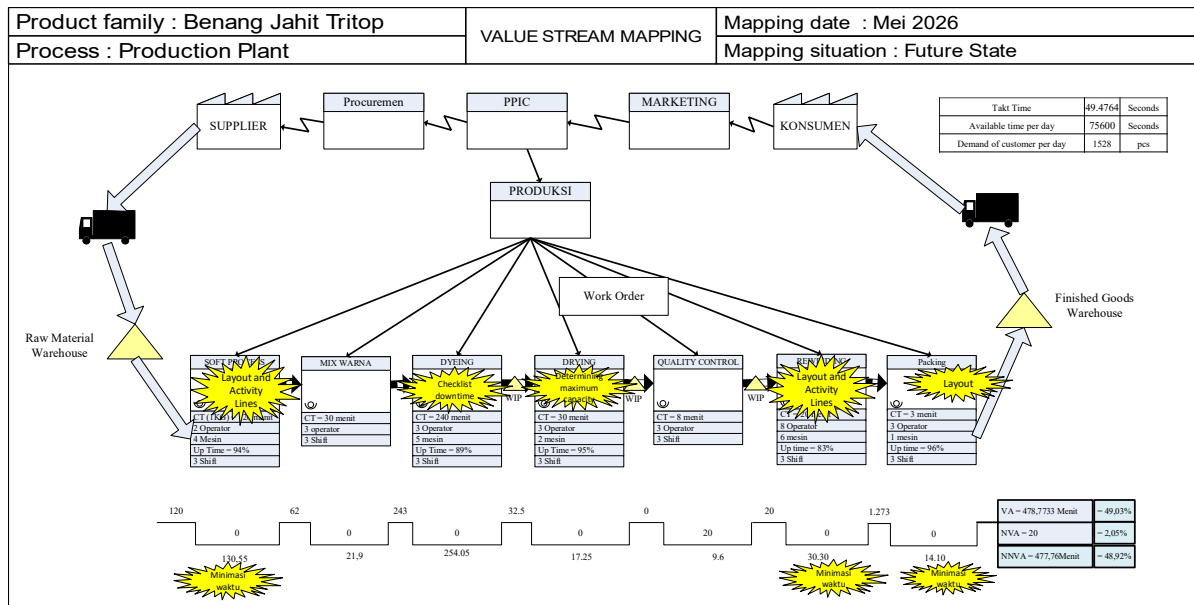
Stasiun	From	To	Distance (m) Before	Distance (m) After
Soft proses	Thread pickup in the basket	Machine	3.6	3.6
	Taking the chest in the basket	Machine	3	3

Stasiun	From	To	Distance (m) Before	Distance (m) After
	Monitoring the right spindle	Spindel left	8	2.5
	Machine	Scale	4	2.5
	Scale	Soft result basket	3	1.9
	Soft result basket	Soft result rack	4	4
Winding	Taking thread from the basket	Machine	3.1	1.03
	Taking the chest in the basket	Machine	3.2	1.03
	Monitoring the right spindle	Spindel left	6	6
	Scale	Machine	3	1.12
Packing	Temporary storage of the machine	shelf result	4	4
	Packing	Scan Packing	39	13
TOTAL			83.9	43.68

From the calculations above, it is known that it can reduce distance and time. Thus, layout and workflow improvements can enhance the smoothness and effectiveness of the production process.

Future State Mapping

Future State Mapping is developed based on the proposed improvements that have been made, including layout changes, reduction of transfer distances, workflow adjustments, and elimination of non-value-added activities [14]. The improvement results show that the process flow has become smoother, material transfer more efficient, and the process time shorter, thereby increasing the effectiveness of the production process [15].



Picture 7. Future State Mapping

4. Conclusions and Recommendations

Conclusions

Identification of waste in the Tritop sewing thread production process at PT. XYZ using Value Stream Mapping (VSM) and Process Activity Mapping (PAM) identified three dominant types of waste: waiting waste at the soft process and dyeing stations, inventory waste in the dyeing-drying and drying-winding buffer areas, and motion waste at the winding and packing stations.

The Root Cause Analysis (RCA) using a fishbone diagram showed that waiting waste was caused by machine downtime, an imbalance between machine and operator capacity, and suboptimal batch grouping. Inventory waste was caused by capacity imbalances between workstations and the absence of WIP control, while motion waste was mainly caused by a suboptimal facility layout.

The proposed improvements through Future State Mapping (FSM), including inventory control, facility layout improvement, and preventive maintenance, resulted in a reduction in total transfer distance from 83.9 m to 43.68 m, equivalent to a reduction of 47.94%. In addition, the NNVA activity time decreased from 478.4 minutes to 477.7 minutes. These results indicate that the proposed improvements

can reduce unnecessary movement and support a more efficient production flow.

Suggestions

The company is advised to implement the Future State Mapping (FSM) improvement proposal gradually through layout improvements, Work In Process (WIP) control, production scheduling, and preventive maintenance to reduce waste and increase production process efficiency. Further research can develop the analysis using other lean methods to make the improvement results more optimal.

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