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Lean Manufacturing Reduces Waste in Hair Coloring Shampoo Production

Tiara Anugerah, 22032010079@student.upnjatim.ac.id (*)

Department of Industrial Engineering, UPN "Veteran" East Java, Indonesia

Rusindiyanto Rusindiyanto, rusindiyanto.ti@upnjatim.ac.id

Department of Industrial Engineering, UPN "Veteran" East Java, Indonesia

(*) Corresponding author

Abstract

General Background: Production inefficiency remains a major concern in manufacturing because waste can increase process duration, resource use, and operational costs. **Specific Background:** PT XYZ, a cosmetic manufacturing company producing hair coloring shampoo, experienced production waste involving high waiting time, repetitive activities, unnecessary inventory, overproduction, product defects, excessive transportation, unnecessary motion, and overprocessing. **KnowledgeGap:** Previous lean manufacturing studies have commonly emphasized Value Stream Mapping, while limited work has combined process mapping with deeper root cause analysis in the cosmetics sector. **Aims:** This study aimed to analyze waste in the hair coloring shampoo production process using lean manufacturing, Value Stream Mapping, VALSAT, Process Activity Mapping, fishbone diagrams, and 5 Whys Analysis. **Results:** The initial production process had a total lead time of 897 minutes and a Process Cycle Efficiency value of 28.09%. The dominant wastes were overproduction with a score of 3, unnecessary inventory with a score of 3, and waiting with a score of 2.33. After proposed improvements, total lead time decreased to 673 minutes, while Process Cycle Efficiency increased to 37.44%. Non-value-added and necessary but non-value-added activities decreased by 57.95% and 18.64%, respectively. **Novelty:** This study integrates Value Stream Mapping with fishbone diagrams and 5 Whys Analysis to diagnose waste sources in cosmetic product manufacturing. **Implications:** The findings support better scheduling, quality control coordination, procedure simplification, inventory control, ergonomic layout design, and regular 5S implementation.

Highlights:

- PCE rose from 28.09% to 37.44% after proposed changes.
- Overproduction, unnecessary inventory, and waiting ranked as the main wastes.
- NVA and NNVA activities declined by 57.95% and 18.64%.

Keywords: Lean Manufacturing, Process Cycle Efficiency, Root Cause Analysis, Value Stream Mapping, Waste

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Introduction

The production process is a series of activities in the manufacturing industry aimed at transforming raw materials into finished products through interconnected stages. The cosmetic industry is one of the most important and rapidly growing sectors in the global economy, with cosmetic products becoming part of daily necessities for both men and women [1]. In the production process, companies generally still experience waste [2]. Waste refers to the loss of resources such as materials, time, and capital caused by activities that do not provide added value to the final product. Therefore, waste must be minimized or eliminated because it can reduce productivity and negatively affect the company's profitability [3].

The company under study is a manufacturing firm engaged in the cosmetic industry, focusing on the development and production of hair care products. One of the products produced is hair coloring shampoo. In its production process, the company still encounters several issues indicating the presence of waste. These conditions are reflected in activities that potentially generate waste, such as product defects, inventory accumulation, and discrepancies between production quantities and sales levels. This situation indicates inefficiencies within the production flow. Such waste has an impact on increased production lead time, additional rework activities, and suboptimal use of resources, including operator working time, raw materials, and machine capacity. Furthermore, the significant amount of product flaws leads to higher manufacturing expenses and lowers the efficiency and effectiveness of the production workflow.

While earlier research has covered the use of lean manufacturing for minimizing waste, a majority of these studies mainly emphasize process mapping through Value Stream Mapping (VSM) without the backing of thorough root cause analysis, especially within the cosmetics sector. This suggests a gap in research that calls for a more extensive approach suited to the specific circumstances of businesses. Based on these problems, this study aims to analyze waste in the production process flow using a lean manufacturing approach. The main objective of lean manufacturing is to eliminate waste or non-value-added activities within a process so that activities throughout the value stream are able to generate value-added outcomes [4]. This concept is used to reduce waste by categorizing activities into value-added, non-value-added, and necessary but non-value-added activities, utilizing the Value Stream Mapping (VSM) tool [5]. VSM is considered an effective method for identifying waste and demonstrating process improvement opportunities within a company's production system [6].

Furthermore, to identify the root causes of waste, this study also applies Root Cause Analysis (RCA) using a cause-and-effect (fishbone) diagram and the 5 Whys method. Root Cause Analysis (RCA) is a structured approach used to identify the contributing factors behind one or more problems in order to improve organizational performance. In order to conduct more focused corrective actions, the fishbone diagram is used to identify the variables causing defects, including aspects relating to labor, machinery, processes, materials, and the work environment [7]. In addition, the 5 Whys method is used to facilitate a deeper investigation of the root causes by repeatedly asking "why" continuously until the core reason of the issue is found, the 5 Whys method helps to allow a deeper analysis of the main issues [8]. This approach's simplicity stems from the fact that it doesn't require sophisticated supporting tools, which makes it simple to apply by different parties in problem-solving processes and capable of promoting critical thinking and team discussions to swiftly discover core issues [9]. Through the implementation of VSM and root cause analysis, this research is expected to reduce waste in the production process and provide appropriate improvement recommendations to enhance the company's operational performance.

Method

Data processing was conducted to analyze waste in the production process flow of hair coloring shampoo products at PT XYZ based on production activity data, process times, and the causes of waste occurring during the production process. The method used in this study was lean manufacturing with the Value Stream Mapping (VSM) approach to identify value-added and non-value-added activities within the production flow. In addition, root cause analysis was carried out using Root Cause Analysis (RCA) supported by fishbone diagrams and the 5 Whys Analysis method as the basis for developing improvement recommendations. The stages carried out in this research are explained as follows:

1. Data Collection

The data collection stage was conducted to obtain the information required in this study. The data used were primary data obtained directly through observations and interviews in the production area of PT Aestika Marwa Indonesia. The collected data consisted of production process flow data and production process time data. Production process flow data were used to determine the sequence of activities as well as the flow of materials and information during the production process, starting from raw material receiving to finished products. Meanwhile, production process time data were obtained by observing and recording the time required for each production activity, which was used as the basis for calculating production lead time and Process Cycle Efficiency (PCE).

2. Current State Value Stream Mapping Analysis

At this stage, Current State Value Stream Mapping was developed to describe the initial condition of the production process flow based on activity and production time data. Current State VSM was used to identify value-added and non-value-added activities and to determine the actual condition of the production process. Furthermore, Process Cycle Efficiency (PCE) was calculated. Process Cycle Efficiency (PCE) is a comparison between value-added activities and total lead time. A process can be categorized as lean if the PCE value is greater than 30% using the following formula [10]:

$$PCE = \frac{\text{Value Added}}{\text{Total Lead Time}} \times 100\% \quad (1)$$

3. VALSAT Weighting Score

VALSAT weighting score was carried out to determine the types of waste that had the greatest influence on the production process. The waste weight values were obtained from questionnaire data completed by respondents, which were then calculated and classified into each type of waste.

4. VALSAT Score Calculation

Value Stream Analysis Tools (VALSAT) is a tool used to understand the flow of materials and information throughout the production process by identifying the seven types of waste. In the VALSAT method, each waste type is assigned a weight value. The waste weights are multiplied by correlation values consisting of ordinal scales categorized as low, medium, and high, with multiplier values of 1, 3, and 9, respectively [11].

$$\text{VALSAT Tool Score} = \text{Waste Weight} \times \text{Correlation Value (H, L, M)} \quad (2)$$

Information:

Waste Weight = Waste weight value obtained from questionnaire calculation results

Correlation Value = H (High Correlation and Usefulness) = 9

M (Medium Correlation and Usefulness) = 3

L (Low Correlation and Usefulness) = 1

5. Selected VALSAT Tools Analysis

At this stage, analysis was carried out using the VALSAT tool with the highest score. The selected tool was used to identify production activities categorized as Value Added (VA), Non-Value Added (NVA), and Necessary but Non-Value Added (NNVA).

6. Fishbone Diagram

This stage was conducted to identify the factors causing waste using a fishbone diagram. The analysis considered several aspects, including man, machine, method, material, environment, and measurement.

7. 5 Whys Analysis

The 5 Whys method was used to investigate the root causes of waste more deeply by repeatedly asking “why” until the main cause of the waste was identified.

8. Development of Future State Value Stream Mapping

This stage involved developing Future State Value Stream Mapping to describe the condition of the production process flow after the implementation of improvement recommendations. Future State Mapping represents the Value Stream Mapping condition after improvements have been implemented. The improvements refer to the application of the proposed recommendations and the recalculation of Process Cycle Efficiency (PCE) values [12].

Result and Discussion

A. Production Activity Time Data

The production activity time data were obtained through direct observation of each production process activity[13]. The data include the processing time required at each workstation and are used as the basis for analyzing production lead time and identifying waste in the production flow, as shown in Table 1.

Table 1. Production Activity Time Data

No	Activity	Time (minutes)
Material Warehouse & Production Preparation		
1	Issuance of production plan	4
2	Waiting for administrative process	12
3	Transfer of raw materials from warehouse storage racks	15
Weighing Test		
4	Transfer of materials to the production area	15
5	Operator receives materials from the warehouse along with Goods Receipt Note	2
6	Transfer of materials to the weighing room	3

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7	Preparation of weighing equipment and tools	10
8	Waiting for weighing queue	20
9	Weighing of raw materials according to formulation	22
10	Verification of weighing results	4
11	Input and checking of weighing data	15
12	Temporary packaging of weighed materials	12
Mixing		
13	Transfer of materials to the mixing room	18
14	Checking material conformity with production formulation	2
15	Preparation of materials before mixing	8
16	Mixing machine setup	30
17	Waiting for mixing machine readiness	15
18	Heating process of materials	15
19	Mixing process using mixing machine	75
20	Monitoring and adjusting mixing parameters	6
21	Vacuum process to remove air bubbles and impurities	15
22	Inspection of mixing results by operator	12
23	Transfer of mixing results from main tank to temporary containers (drums/small tanks)	17
24	Batch labeling and production time marking	4
25	Temporary storage of products in WIP area before filling	75
Filling		
26	Transfer of products to the filling room	5
27	Checking batch conformity and product volume before filling	6
28	Request for bottles from warehouse	12
29	Transfer of bottles and caps from packaging warehouse to filling area	4
30	Arrangement of empty bottles in filling area	15
31	Preparation of filling machine	5
32	Filling process into bottles	30
33	Bottle capping process	15
34	Inspection of filling results	15
35	Arrangement of filled products before finishing	8
36	Temporary storage before finishing	40
Finishing		
37	Transfer of products to finishing conveyor	7
38	Labeling process on bottles	40
39	Inner packaging process	25
40	Transfer of products to shrink station	4
41	Shrink wrapping process	15
42	Inspection of finishing results	18
43	Transfer of products to outer packaging area	4
44	Packaging into outer cartons	80
Palletizing		
45	Transfer of cartons to palletizing area	18
46	Arrangement of products on pallets	40
47	Checking the quantity of finished products	12
48	Preparation and issuance of delivery PO for finished goods	6
49	Preparation and completion of Goods Receipt Note	2
50	Waiting for warehouse administrative process	25
51	Transfer of finished goods to finished goods warehouse	20

B. Current State Value Stream Mapping

The current state value stream mapping of the production process can be seen in Figure 1.

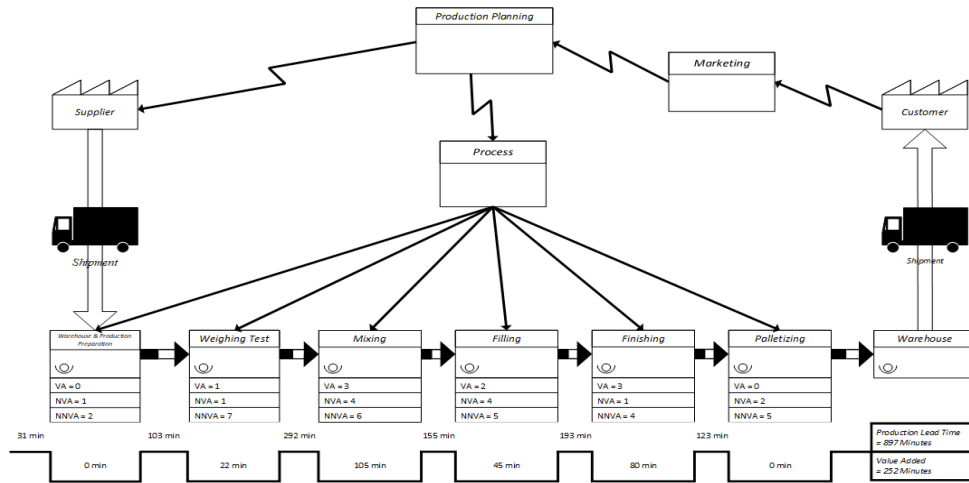


Figure 1. Current State Value Stream Mapping

The production process has a total lead time of 897 minutes, with a value-added time of 252 minutes. The Process Cycle Efficiency (PCE) is calculated as follows:

$$PCE = \frac{\text{Value Added}}{\text{Total Lead Time}} \times 100\%$$

$$PCE = \frac{252}{897} \times 100\% = 28,09\%$$

C. VALSAT Weighting Score

The weighting of waste is conducted to identify the types of waste that have the greatest impact on the production process [14]. The waste weights are obtained from questionnaire data completed by respondents, which are then calculated and classified into each type of waste. The recapitulation of waste weights is presented in Table 2.

Table 2. Waste Weight Recapitulation

No	Waste	Respondent			Average Score	Ranking
		1	2	3		
1	<i>Over Production</i>	4	4	1	3	1
2	<i>Unnecessary Inventory</i>	4	4	1	3	2
3	<i>Waiting</i>	1	2	4	2,33	3
4	<i>Unnecessary Motion</i>	3	2	1	2	4
5	<i>Defect</i>	1	2	1	1,33	5
6	<i>Excessive Transportation</i>	1	1	1	1	6
7	<i>Over Processing</i>	1	0	1	0,67	7

Based on the calculated waste weights, an analysis is conducted for each type of waste occurring in the production process. These weights indicate the contribution level of each type of waste to the overall inefficiency within the production system.

D. VALSAT Score Calculation

The data is then processed by multiplying the waste weights by the values in each column of the VALSAT matrix once the weight of each type of waste has been determined. The results of the VALSAT score calculation are presented in Table 3.

Table 3. VALSAT Score Calculation

No	Waste	Weight	Mapping Tools						
			PAM	SCRM	PVF	QFM	DAM	DPA	PS
1	<i>Over Production</i>	3	3	9	-	3	9	9	-
2	<i>Unnecessary Inventory</i>	3	9	27	9	-	27	9	3
3	<i>Waiting</i>	2,33	21	21	2,3	-	7	7	-
4	<i>Unnecessary Motion</i>	2	18	2	-	-	-	-	-
5	<i>Defect</i>	1,33	1,3	-	-	11,7	-	-	-
6	<i>Excessive Transportation</i>	1	9	-	-	-	-	-	1
7	<i>Over Processing</i>	0,67	6	-	2	0,67	-	0,67	-
	Total	13,3	67,3	59	13,3	15,4	43	25,7	4

The following formula is used to determine the VALSAT score after the weight of each type of waste has been obtained:

$$\text{VALSAT Tool Score} = \text{Waste Weight} \times \text{Correlation Value}$$

The correlation values are defined as follows: High (H) = 9, Medium (M) = 3, and Low (L) = 1. Based on the computation results, Process Activity Mapping (PAM) has the highest score, with a total value of 67.3.

E. Process Aktivitas Mapping (PAM)

The Process Activity Mapping (PAM) method focuses on identifying and reducing non-value-added activities in the production process through elimination, simplification, or improvement of workflow[15]. The mapping results are summarized in Table 4.

Table 4. Process Activity Mapping

No	Activity	Type of Activity					Time (Minutes)	Category
		O	T	I	S	D		
Material Warehouse & Production Preparation								
1	Issuance of production plan	✓					4	NNVA
2	Waiting for administrative process					✓	12	NVA
3	Transfer of raw materials from warehouse storage racks		✓				15	NNVA
Weighing Test								
4	Transfer of materials to the production area		✓				15	NNVA
5	Operator receives materials from the warehouse along with Goods Receipt Note	✓					2	NNVA
6	Transfer of materials to the weighing room		✓				3	NNVA
7	Preparation of weighing equipment and tools	✓					10	NNVA
8	Waiting for weighing queue					✓	20	NVA
9	Weighing of raw materials according to formulation	✓					22	VA
10	Verification of weighing results			✓			4	NNVA
11	Input and checking of weighing data			✓			15	NNVA
12	Temporary packaging of weighed materials				✓		12	NNVA
Mixing								
13	Transfer of materials to the mixing room		✓				18	NNVA
14	Checking material conformity with production formulation			✓			2	NVA
15	Preparation of materials before mixing				✓		8	NNVA
16	Mixing machine setup	✓					30	NNVA
17	Waiting for mixing machine readiness					✓	15	NVA
18	Heating process of materials	✓					15	VA
19	Mixing process using mixing machine	✓					75	VA
20	Monitoring and adjusting mixing parameters	✓					6	NNVA
21	Vacuum process to remove air bubbles and impurities	✓					15	VA
22	Inspection of mixing results by operator			✓			12	NVA
23	Transfer of mixing results from main tank to temporary containers (drums/small tanks)		✓				17	NNVA
24	Batch labeling and production time marking	✓					4	NNVA
25	Temporary storage of products in WIP area before filling				✓		75	NVA
Filling								
26	Transfer of products to the filling room		✓				5	NNVA
27	Checking batch conformity and product volume before filling			✓			2	NNVA
28	Request for bottles from warehouse	✓					2	NVA
29	Transfer of bottles and caps from packaging warehouse to filling area		✓				5	NVA
30	Arrangement of empty bottles in filling area	✓					4	NNVA
31	Preparation of filling machine	✓					9	NVA
32	Filling process into bottles	✓					6	NNVA
33	Bottle capping process	✓					5	NNVA
34	Inspection of filling results			✓			55	VA
35	Arrangement of filled products before finishing				✓		25	NNVA

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36	Temporary storage before finishing				✓		10	NVA
Finishing								
37	Transfer of products to finishing conveyor		✓				7	NNVA
38	Labeling process on bottles	✓					40	VA
39	Inner packaging process	✓					25	VA
40	Transfer of products to shrink station		✓				4	NNVA
41	Shrink wrapping process	✓					15	VA
42	Inspection of finishing results			✓			18	NVA
43	Transfer of products to outer packaging area		✓				4	NNVA
44	Packaging into outer cartons	✓					80	NNVA
Palletizing								
45	Transfer of cartons to palletizing area		✓				18	NNVA
46	Arrangement of products on pallets	✓					40	NNVA
47	Checking the quantity of finished products			✓			12	NVA
48	Preparation and issuance of delivery PO for finished goods	✓					6	NNVA
49	Preparation and completion of Goods Receipt Note	✓					2	NNVA
50	Waiting for warehouse administrative process					✓	25	NVA
51	Transfer of finished goods to finished goods warehouse		✓				20	NNVA

The notations used are defined as follows: O represents operation, T represents transportation, I represents inspection, S represents storage, and D represents delay. In addition, VA refers to value-added activities, NVA refers to non-value-added activities, and NNVA refers to necessary but non-value-added activities.

Based on these classifications, PAM groups all identified activities into three main categories: value-added activities, necessary but non-value-added activities, and non-value-added activities. This approach enables the identification of non-value-added activities, which can then be minimized or eliminated to improve operational efficiency. The percentage of time and frequency for each activity type is shown in Table 5.

Table 5. Percentage of Time and Frequency for Each Activity Type

No	Activity Type	Time (Minutes)	Percentage	Frequency	Percentage
1	Operation	468	52,17%	22	43,14%
2	Transportation	130	14,49%	12	23,53%
3	Inspection	84	9,36%	8	15,69%
4	Storage	143	15,94%	5	9,80%
5	Delay	72	8,03%	4	7,84%
Total		897	100%	51	100%

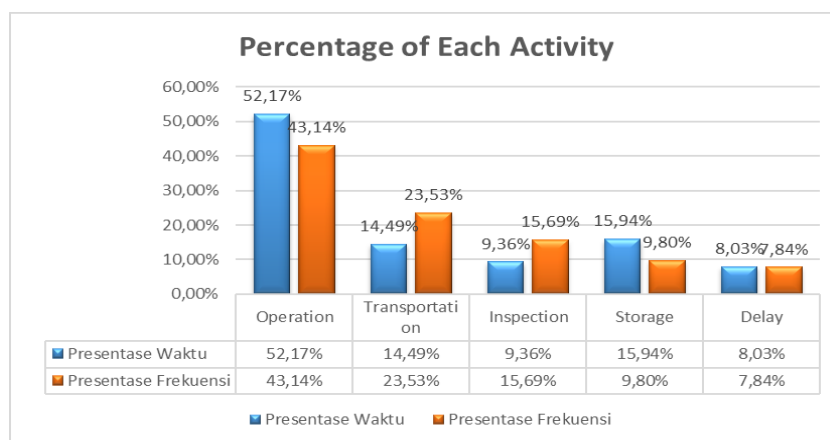


Figure 2. Percentage of Time and Frequency by Activity Type

Subsequently, all activities are categorized into Value-Added (VA), Non-Value-Added (NVA), and Necessary but Non-Value-Added (NNVA) to assess the efficiency of the production process. The classification results are presented in Table 6.

Table 6. Percentage of Time and Frequency by Activity Type

No	Activity Type	Time (Minutes)	Percentage	Frequency	Percentage
1	<i>Value Added Activity</i>	252	28,09%	9	17,65%
2	<i>Non Value Added Activity</i>	264	29,43%	13	25,49%
3	<i>Necessary but Non Value Added Activity</i>	381	42,47%	29	56,86%
Total		897	100%	51	100%

The comparison of the percentage of time and frequency by activity type is illustrated in Figure 3.

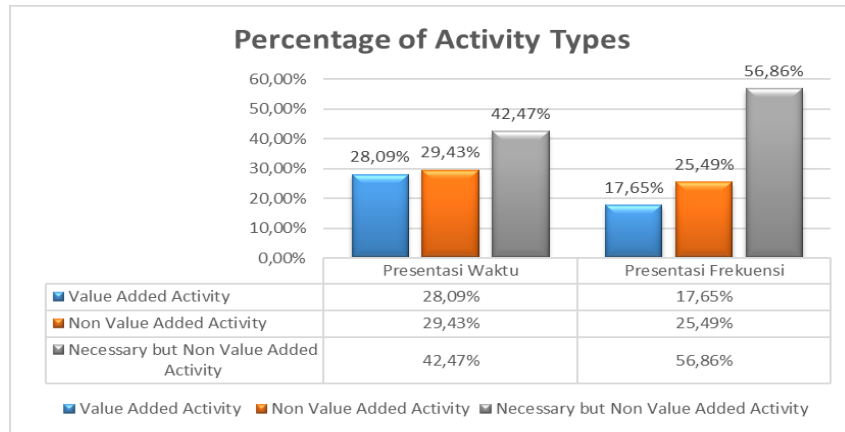


Figure 3. Percentage of Time and Frequency by Activity Type

F. Fishbone Diagram

The fishbone diagram for overproduction waste is presented in Figure 4.

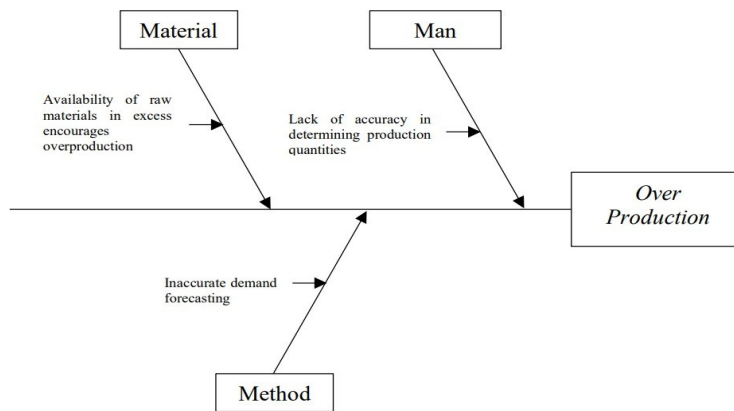


Figure 4. Fishbone Diagram Waste of Over Production

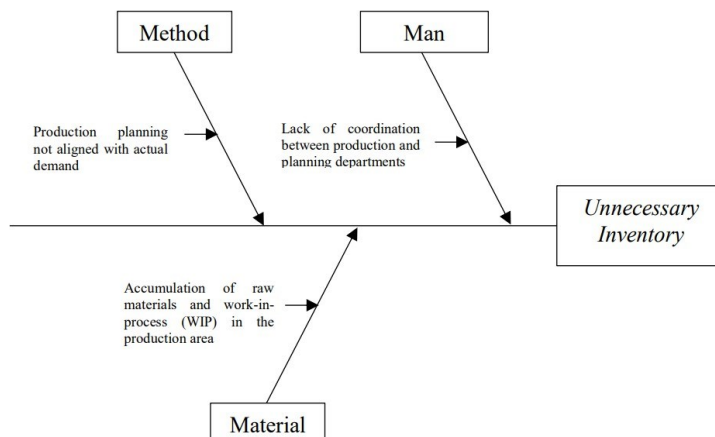


Figure 5. Fishbone Diagram Waste of Unnecessary Inventory

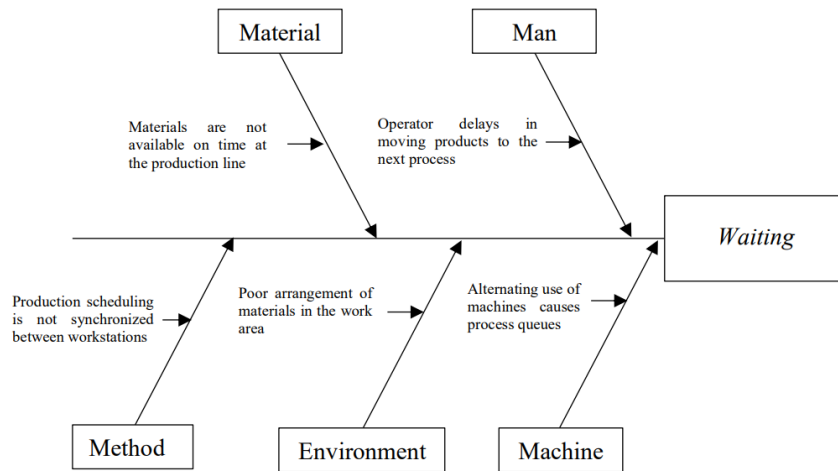


Figure 1. Fishbone Diagram Waste of Waiting

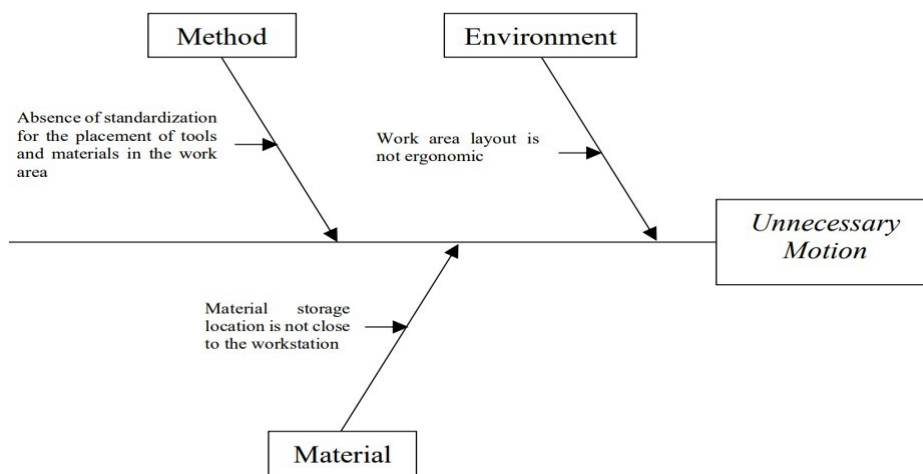


Figure 7. Fishbone Diagram Waste of Unnecessary Motion

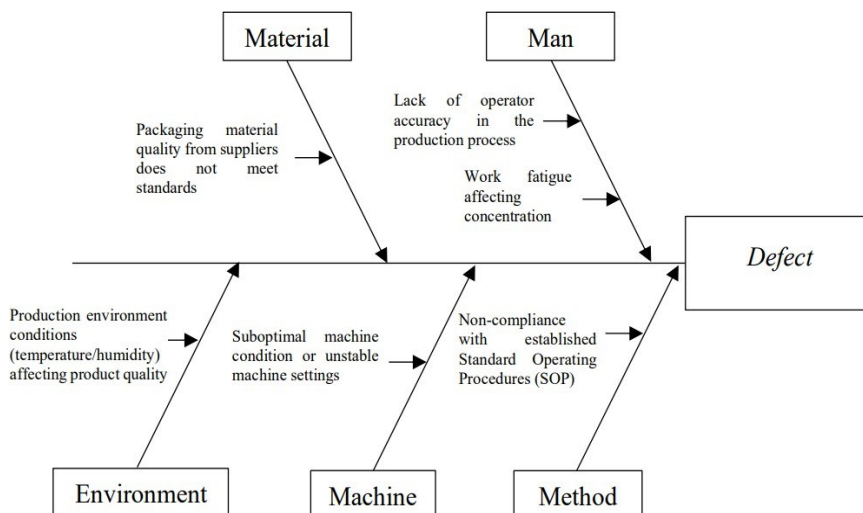


Figure 8. Fishbone Diagram Waste of Defect

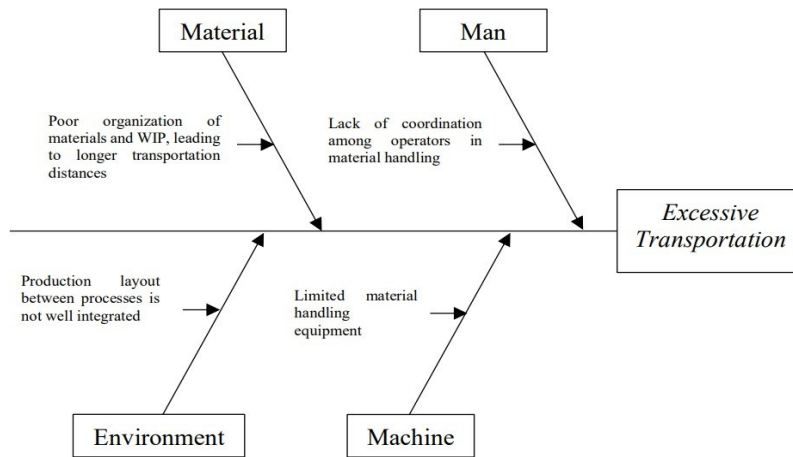


Figure 9. Fishbone Diagram Waste of Excessive Transportation

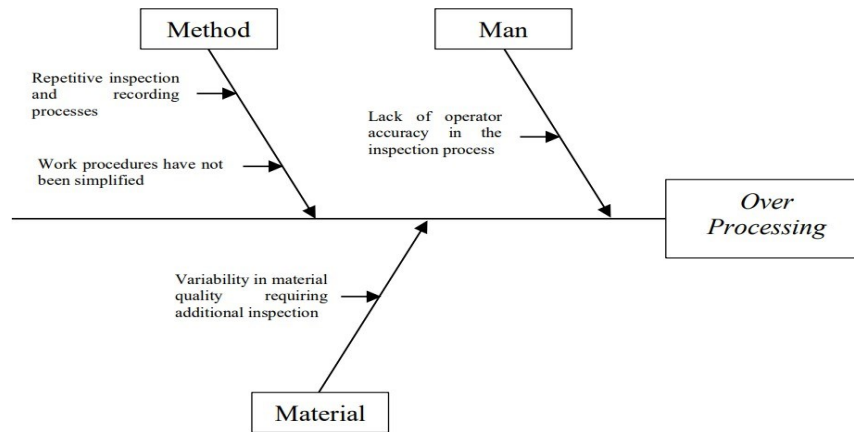


Figure 10. Fishbone Diagram Waste of Over Processing

G. 5 Whys Analysis

Based on the identified wastes from the previous stage, a 5 Whys Analysis is conducted to determine the root causes of each problem occurring in the production process. This analysis is performed by repeatedly asking “why” in a step-by-step manner until the fundamental cause of the waste is identified. The results of the 5 Whys Analysis are presented in Table 7.

Table 7. 5 Whys Analysis

Waste	Subwaste	Why 1	Why 2	Why 3	Why 4	Why 5
Waiting	Waiting for production process queue	Queues occur between workstations	Due to unbalanced process capacity	Due to absence of line balancing	Due to suboptimal capacity planning	Due to lack of workload analysis
	Waiting for materials	Materials are not available when needed	Due to delayed material delivery	Due to poor coordination between warehouse and production	Due to absence of material control system	Due to lack of pull system implementation
Excessive Transportation	Material transfer between areas	Materials are frequently moved	Due to long distances between production areas	Due to non-sequential layout	Due to layout not based on process flow	Due to lack of production layout evaluation
	Repeated back-and-forth movement	Products are moved before the next process	Due to unstable WIP placement	Due to absence of standard storage area	Due to lack of material flow regulation	Due to suboptimal facility planning
Over Processing	Repeated inspection	Inspections are performed more than once	Due to lack of confidence in previous results	Due to unclear inspection standards	Due to non-standardized SOP	Due to lack of process standardization
	Repeated	Data are	Due to manual	Due to absence	Due to lack of	Due to

	recording	recorded multiple times	system	of integrated system	process digitalization	limitations in information systems
	Rehandling of products	Products must be cleaned or reworked before the next process	Due to dirty products or damaged labels	Due to spillage during filling process	Due to lack of operator accuracy	Due to absence of consistent quality control system
Unnecessary Motion	Excessive operator movement	Operators frequently change positions	Due to tools not located near work area	Due to non-ergonomic layout	Due to absence of standard work layout	Due to lack of 5S implementation
	Non-ergonomic movement	Operators frequently bend or reach	Due to improper material positioning	Due to disorganized storage	Due to absence of placement standards	Due to lack of workplace supervision
Defect	Products not meeting specifications	Inconsistent production results	Due to suboptimal final inspection	Due to lack of detailed inspection standards	Due to poorly documented quality control procedures	Due to lack of continuous evaluation and improvement
	Errors in production process	Errors occur during processing	Due to lack of operator accuracy	Due to insufficient training	Due to absence of performance evaluation	Due to weak quality control system
Over Production	Production exceeds demand	Products are produced beyond demand	Due to inaccurate planning	Due to outdated demand data	Due to lack of proper forecasting	Due to poor data integration
	Production for stock	Production is carried out for inventory	Due to fear of stock shortages	Due to absence of min-max stock limits	Due to lack of production limits	Due to absence of demand-based production adjustment
Unnecessary Inventory	Waiting for production process queue	Queues occur between workstations	Due to unbalanced process capacity	Due to absence of line balancing	Due to suboptimal capacity planning	Due to lack of workload analysis
	Waiting for materials	Materials are not available when needed	Due to delayed material delivery	Due to poor coordination between warehouse and production	Due to absence of material control system	Due to lack of pull system implementation

The results of the fishbone diagram and 5 Whys analysis indicate several root causes of waste occurring in the production process flow, particularly in waiting, excessive transportation, overprocessing, and unnecessary motion, which contribute the most to the total waste time. Therefore, improvement recommendations are required to focus on reducing non-value-added activities and enhancing the efficiency of the production process. The proposed improvement recommendations are summarized in Table 8.

Table 8. Improvement Recommendations

Waste	Activity	Improvement Recommendation
Waiting	Waiting time occurs during quality testing, machine readiness, and production scheduling	Develop clear inter-process daily schedules, establish standard time for QC testing, and improve coordination between production and quality control to accelerate process flow
Overprocessing	Repetitive recording and inspection activities	Simplify work procedures by eliminating redundant activities, reduce rework by improving operator accuracy, utilize digital recording systems (e.g., ERP or barcode-based), and implement a single primary inspection by QC to avoid repeated checks
Defects	Product quality nonconformities during mixing and filling processes	Add visual checkpoints for packaging materials (e.g., bottle sorting), improve process parameter control, provide training and simple work instructions to operators, and collaborate with suppliers to ensure packaging quality standards
Overproduction	Production exceeds demand, resulting in product accumulation	Establish daily production limits based on sales data (limited make-to-stock) and conduct weekly stock reviews with warehouse and marketing departments
Excessive Transportation	Repeated movement of materials and products over long distances	Improve production layout based on process sequence and define standardized, efficient material flow paths to reduce unnecessary back-and-forth movement
Unnecessary Motion	Inefficient operator movement in handling tools and materials	Design an ergonomic work layout (frequently used tools placed near operators), label tool and material locations, and implement 5S

		regularly
Unnecessary Inventory	Accumulation of work-in-process before the next stage	Control inventory levels by setting WIP limits and evaluate production flow to prevent accumulation

H. Development of Future State Value Stream Mapping

The adjustment of production activity time after the implementation of improvement recommendations is shown in Table 9.

Table 9. Adjustment of Production Activity Time for Hair Coloring Shampoo

No	Activity	Time (Minutes)	
		Before	After
1	Waiting for administrative process	12	5
2	Transfer of raw materials from warehouse storage racks	15	7
3	Transfer of materials to the production area	15	7
4	Waiting for weighing queue	20	10
5	Input and checking of weighing data	15	8
6	Transfer of materials to the mixing room	18	9
7	Waiting for mixing machine readiness	15	8
8	Inspection of mixing results by operator	12	5
9	Temporary storage of products in WIP area before filling	75	15
10	Inspection of filling results	15	7
11	Temporary storage before finishing	40	10
12	Inspection of finishing results	18	9
13	Packaging into outer cartons	80	60
14	Transfer of cartons to palletizing area	18	9
15	Waiting for warehouse administrative process	25	10
16	Transfer of finished goods to finished goods warehouse	20	10

By implementing these improvements, the total lead time is reduced from 897 minutes to 673 minutes, resulting in a reduction of 224 minutes. This reduction contributes to a more streamlined production flow and improves overall process performance. The future state value stream mapping is illustrated in Figure 11.

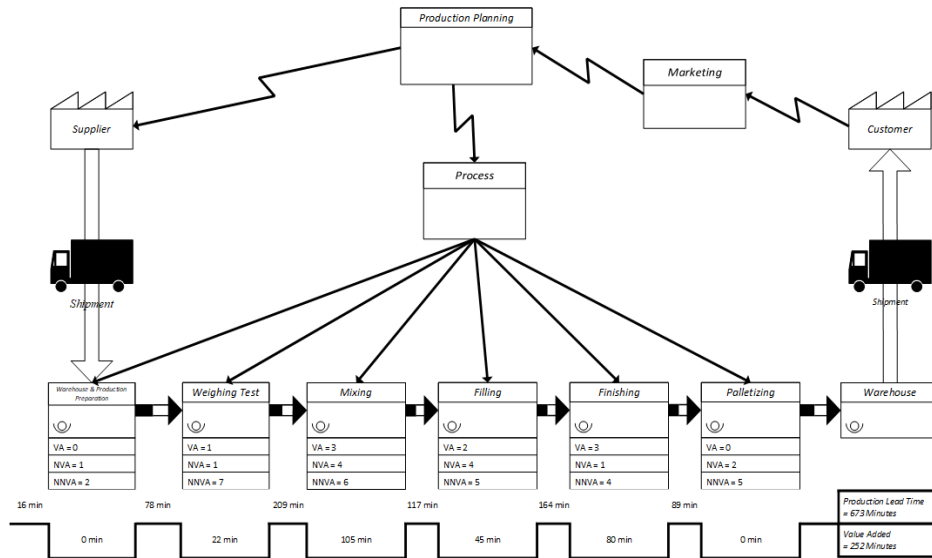


Figure 11. Future State Value Stream Mapping

To assess the performance of the production process after improvement, the Process Cycle Efficiency (PCE) is calculated as follows:

$$PCE = 100\%$$

$$PCE = 100\% = 37,44\%$$

The calculation results show that the Process Cycle Efficiency (PCE) increased from 28.09% in the current state condition to 37.44% after the implementation of the proposed improvements.

Conclusion

This study demonstrates that the implementation of the lean manufacturing approach was effective in identifying and reducing waste within the hair coloring shampoo production process at PT XYZ. The analysis results indicate that the most

dominant wastes were overproduction (score 3), unnecessary inventory (score 3), and waiting (score 2.3). These wastes contributed to inefficiencies in the production flow, increased production lead time, and accumulation of work-in-process and finished goods. Value Stream Mapping (VSM), Process Activity Mapping (PAM), VALSAT, and Root Cause Analysis (RCA) were used to successfully identify non-value-added activities and the root causes of waste occurring throughout the production process.

With a Process Cycle Efficiency (PCE) rating of 28.09% and an initial production lead time of 897 minutes, the Process Activity Mapping (PAM) analysis revealed that the manufacturing process had not yet reached ideal efficiency. Following the suggested changes, the PCE value rose to 37.44% and the manufacturing lead time dropped to 673 minutes. Value-Added (VA) activities did not change, whereas Non-Value-Added (NVA) and Necessary but Non-Value-Added (NNVA) activities dropped by 57.95% and 18.64%, respectively. Therefore, the lean manufacturing approach can be considered effective in reducing waste and improving operational performance in the production process at PT XYZ.

These results show that the proposed improvements successfully improved production flow efficiency by reducing non-value-added activities and minimizing production delays. The proposed improvement actions focused on improving inter-process scheduling, strengthening coordination between production and quality control, simplifying operational procedures, reducing rework, optimizing inventory management, and applying ergonomic work design and 5S principles. Further research is recommended to evaluate the long-term effectiveness of the proposed improvements and support continuous improvement in production system performance.

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