



Url : <https://itej.uinssc.ac.id>
 Email : itej@svekhnurjati.ac.id

Analysis of Waste in Plastic Packaging Products Warehousing Activities Using a Lean Warehousing Approach

Clairine Aurellia Sanjaya
 Industrial Engineering
 Universitas Pembangunan Nasional “Veteran”
 Jawa Timur Surabaya
clairinearellia535@gmail.com

Dira Ernawati
 Industrial Engineering
 Universitas Pembangunan Nasional “Veteran”
 Jawa Timur Surabaya
dira.ti@upnjatim.ac.id

Abstract—The manufacturing industry is required to meet customer demands quickly and precisely in the midst of fierce competition, so efficient operations are needed. However, inventory buildup occurs due to uncertainty in delivery schedules, resulting in inefficient conditions. This condition leads to various wastes, including excess capacity, product damage, and unnecessary movements, which ultimately increase lead time and reduce warehouse efficiency. This research intends to pinpoint inefficiencies in warehouse operations by employing a lean warehousing strategy with the WAM and VALSAT techniques, while suggesting enhancements through a 5W+1H analysis. The findings indicate that the dominant wastes are inventory (20,21%), overproduction (19,60%), and defects (17,24%). The improvement proposal is focused on improving inventory management through the implementation of a real-time-based barcode/RFID system, which is supported by standardization of work procedures, routine evaluation, layout optimization and determination of storage time limits. The proposed improvements were able to increase efficiency by reducing the processing time by 827 minutes, from 1.881 minutes to 1.054 minutes. The number of activities was also reduced from 43 to 35 activities. In addition, process efficiency has increased, as shown by an increase in Process Cycle Efficiency (PCE) by 1,59%, from 2,02% to 3,61% in warehouse operations

Keywords—Lean Warehouse, Seven Waste, Inventory Warehouse, Waste Assessment Model

Article info: Date Submitted: 23/02/2026 | Date Revised: 03/03/2026 | Date Accepted: 13/04/2026
This is an open access article under the CC BY-SA license



I. Introduction

In an ever-evolving industrial era., warehouses play a critical role in maintaining product quality until the products reach consumers, particularly in ensuring the smooth operation of the supply chain between suppliers and customers [1]. Many essential operations in warehouses necessitate that businesses enhance their productivity to attain higher levels of efficiency and effectiveness, consequently maintaining customer confidence [2]. Warehouses serve to provide storage space for inventory, ranging from semi-finished goods to finished products ready for distribution [3]. Good warehouse management is necessary to maintain a smooth flow of materials, reduce delays, and ensure product availability. Therefore, an efficient warehouse management system is needed to improve distribution efficiency and customer satisfaction.

However, in practice, inefficiencies still occur, particularly in the form of finished goods inventory buildup caused by uncertainty in delivery schedules. As a result, products often remain in storage for extended periods, leading to excessive warehouse capacity. This condition triggers various types of waste, including product damage, unnecessary handling and movements, and additional processes such as rework, which ultimately increase lead time and reduce overall warehouse efficiency.

Earlier studies carried out by Maulana and colleagues in 2025 indicated that employing Value Stream Mapping (VSM) along with the Waste Assessment Model (WAM) proves to be successful in spotting waste in an organization [2]. This research implements a streamlined warehousing strategy in the finished goods storage area, utilizing data evaluation through the Waste Assessment Model (WAM) and Value Stream Analysis Tools (VALSAT). These methods are anticipated to boost efficiency, minimize waste, make better use of storage space, and improve the operational effectiveness of PT. XYZ in fulfilling customer needs.

II. Related Works

A. Warehouse

A warehouse serves as a space for keeping both raw materials and completed products, and its management encompasses all aspects of handling, from receiving and storing to shipping [4]. According to studies, there are three primary categories of warehouses: distribution, production, and contract warehouses, each serving specific roles in storage, movement, and customer service [5]. The aim is to optimize resource utilization and enhance service quality to ensure that products are accessible swiftly and in proper condition [6].

B. Lean Warehousing

Lean warehousing is an approach aimed at minimizing waste throughout the supply chain, both upstream and downstream [7]. Its objective is to improve warehouse efficiency and responsiveness to customer demand by reducing fulfillment time [8]. The implementation of lean warehousing also supports enhancements in both internal and external company performance [9].

C. Waste

Waste pertains to actions that fail to provide value. The idea of seven categories of waste was initially presented by Taiichi Ohno [10]. This includes include overproduction, waiting, transportation, overprocessing, unnecessary inventory, unnecessary motion, and defects [11]. Waste can be defined as any activity in a work process that fails to add value, from converting inputs into outputs to their distribution. These activities do not improve product quality or benefits, but instead increase time and costs without delivering added value to customers [8]. Waste negatively impacts the company by delaying product completion beyond targets while providing no added value (non-value added) [12].

D. Value Stream Mapping

Value Stream Mapping, known as VSM, is a method used to illustrate the complete series of actions in a manufacturing process, encompassing both tasks that add value and those that do not. It shows the journey from initial materials to the finished product delivered to consumers, allowing for the recognition of waste and potential areas for enhancement [13]. In VSM, Process Cycle Efficiency (PCE) is also considered [14]. PCE is a measure that describes how efficiently a process runs [15]. The formula is as follows:

$$PCE = \frac{VA}{\sum t} \times 100\% \quad (1)$$

Where PCE refers to process cycle efficacy, VA signifies the entirety of value-creating activities, and $\sum t$ represents the cumulative lead time.

E. Value Stream Analysis Tools (VALSAT)

Value Stream Analysis Tools are accurate devices employed to pinpoint waste thoroughly within the value stream, concentrating on processes that add value as well as those that do not [16]. This comprehensive chart is utilized to determine the reasons for waste [17]. Each tool is given a classification of low, medium, or high according to its evaluation standards, which helps show how significantly waste influences the chosen map. Furthermore, they help in assessing and examining the kinds of waste that are most prone to happen and offer suggestions for enhancements [18].

F. Waste Assessment Model

The Waste Evaluation Framework helps in recognizing waste using the seven waste categories and examines how various waste types are related. Waste types that are closely linked with others are given priority for reduction or removal since they contribute to non-value-adding activities [19].

1) Seven Waste Relationship (SWR)

This encompasses all waste streams that are interdependent and mutually influence one another. The relationships between these waste streams can be represented using the first letter of each stream, with each relationship denoted by an underscore “_”. For example, O_T indicates that overproduction has a direct effect on transportation [20].

2) Waste Relationship Matrix (WRM)

WRM is a matrix used to assess measurement standards by illustrating the connections between different categories of waste [21]. The lines demonstrate the impact one kind of waste has on different types, whereas the vertical sections reveal the extent of the influence on each waste type. The diagonal features the largest numbers because each waste type is directly connected to itself [15].

3) Waste Assessment Questionnaire (WAQ)

The Waste Assessment Questionnaire comprises 68 questions across the categories of man, machine, method, and material. Every question pertains to a particular action associated with a certain waste type, and the answer choices are assigned values of 1, 0.5, or 0. The findings from the assessment are subsequently utilized to inform the output of the WAM tool [22].

G. 5W+1H

The 5W+1H method is a structured approach for developing action plans by systematically asking questions to identify root causes. It includes six key aspects include What (type of waste), Where (location), When (timing), Who (responsible party), Why (reason), and How (implementation steps) [23].

III. Method

The study and data collection were carried out directly in the finished goods warehouse at PT. XYZ, a plastic packaging manufacturing company that produces based on customer specifications using a Make-to-Order (MTO) system to ensure timely delivery. The dependent variable is the level of waste in warehouse operations, while the independent variables consist of the seven types of waste. Data were gathered through literature review, observation, time studies, interviews, and questionnaire distribution.

Data processing began with the development of a Current State Value Stream Map (CSVSM) to visualize physical and information flows and determine Process Cycle Efficiency (PCE) at PT. XYZ. Questionnaire data were then analyzed using the Waste Assessment Model (WAM) through SWR, WRM, and WAQ to identify critical wastes and their relationships. Further analysis employed selected Value Stream Analysis Tools (VALSAT) to classify activities into value-added, non-value-added, and necessary non-

value-added. Root causes were identified using a fishbone diagram, and improvement proposals were formulated using 5W+1H analysis. Finally, activity simplification was carried out and a Future State Value Stream Map (FSVSM) was developed to represent the improved process, followed by discussion, conclusions, and recommendations for future research.

IV. Result and Discussion

A. Warehouse Process Flow

The following presents data on warehouse flow processes in the finished goods warehouse of PT. XYZ, consisting of six activity categories:

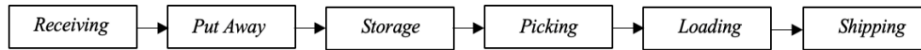


Figure 1. PT XYZ Warehouse Process Flow

B. Warehouse Activity Flow Process

Based on observations of warehouse activities from receiving to delivery, data on processing time, activity types, and total duration are obtained as follows:

Tabel 1. Warehousing Activity Time Data

Code	Activities	Time (Minutes)	Activity Type
Receiving			
A1	Receiving BSTB documents from the production department	3	NNVA
A2	Inspect the quantity of goods received	10	NNVA
A3	Conduct visual and physical quality checks of goods	12	NNVA
A4	Filling out an inspection letter regarding the quality of the goods	5	NNVA
A5	Documenting the results of verification at BSTB	1	NNVA
A6	Placing items in a temporary storage area	4	NNVA
A7	Storing items in a temporary storage area	120	NNVA
A8	Printing the labels of goods that have been verified	5	NNVA
....
Shipping			
F1	Submit the road letter documents to the driver	2	NNVA
F2	Ensuring the goods are safe and closing the delivery truck by the driver	1	NNVA
F3	Document the delivery process	1	NNVA
F4	Report the number of outbound goods and update the goods data on the system	3	NNVA
Total Time (Minutes)		1881	

C. Current State Value Stream Mapping

Once warehousing activities have been identified, the subsequent step is to create a Current State Value Stream Mapping (CSVSM) to depict the actual flow of materials and information throughout the entire warehouse process, as shown in the Figure 2:

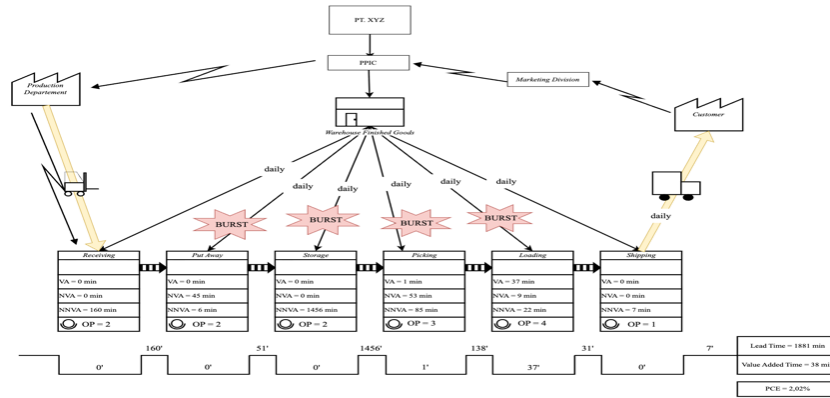


Figure 2. Current State Value Stream Mapping (CSVSM)

From the Figure 2, it is known that the total Process Cycle Efficiency (PCE) in the company PT. XYZ is 2,02%. With the total lead time needed is 1.881 minutes or equivalent to 1 day 7 hours 21 minutes.

D. Waste Assessment Model (WAM)

1) Seven Waste Relationship (SWR)

The following provides a summary of the scores and the nature of relationships among wastes in the warehousing process, derived from the data collected through questionnaires. These figures are utilized to compute the overall average score based on the five respondents:

Tabel 2. Result of Average Score Seven Waste Relationship (SWR)

No.	Relationship Between Waste	Average Score
1.	O I	17,8
2.	O D	11,6
3.	O M	11,8
...
29.	W O	6
30.	W I	6
31.	W D	7,4

2) Waste Relationship Matrix (WRM)

Next, the relationship level is determined by converting the obtained average scores into predefined symbols. A higher total score indicates a stronger correlation between wastes in triggering one another, and vice versa following Tabel 3 below:

Tabel 3. Relationship Between Waste

No.	Relationship Between Waste	Average Score	Relationship Level
1.	O I	17,8	A
2.	O D	11,6	I
3.	O M	11,8	I
...
29.	P W	6	O
30.	W O	6	O
31.	W I	7,4	O

The association weights are divided into five symbol categories, scores of 17–20 = A (Very Important), 13–16 = E (Especially Important), 9–12 = I (Important), 5–8 = O (Ordinary), and 1–4 = U (Not Important). Following the analysis of waste relationships shown in Table 5, the information is subsequently organized into rows and columns in the Waste Matrix Value displayed in Table 4:

Tabel 4. Conversion Results according to the Waste Matrix Value form

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

Additionally, the Waste Matrix Value is expressed as a percentage. The letter F represents "From," while the letter T symbolizes "To. " Each letter is subsequently converted into numerical values according to its classification: A (Absolute) = 10, E (Essential) = 8, I (Important) = 6, O (Occasional) = 4, U (Unimportant) = 2, and X (No Relationship) = 0. Below, the Waste Matrix Value is displayed in its numerical format:

Tabel 5. Waste Relationship Matrix (WRM) Conversion Results

F/T	O	I	D	M	T	P	W	Score	%
O	10	10	6	6	6	0	6	44	18,49
I	6	10	8	8	6	0	0	38	15,97
D	6	4	10	4	4	0	6	34	14,29
M	0	6	6	10	0	6	6	34	14,29
T	4	4	2	6	10	0	6	32	13,45
P	4	4	6	6	0	10	4	34	14,29
W	4	4	4	0	0	0	10	22	9,24
Score	34	42	42	40	26	16	38	238	100
%	14,29	17,65	17,65	16,81	10,92	6,72	15,97	100	

The results indicate that Overproduction (From O) has the highest influence at 18,49%, making it the main source of other wastes. Meanwhile, Inventory (To I) and Defects (To D) have the highest occurrence at 17,65%, showing they are most affected by other wastes.

3) Waste Assessment Questionnaire

The following is a breakdown of the question types used can be seen in Table 6 below:

Tabel 6. Question Type Grouping

No.	Question Type	Total (Ni)
1.	<i>From Overproduction</i>	3
2.	<i>From Inventory</i>	6
3.	<i>From Defect</i>	8
4.	<i>From Motion</i>	11
5.	<i>From Transportation</i>	4
6.	<i>From Process</i>	7
7.	<i>From Waiting</i>	8
8.	<i>To Defects</i>	4
9.	<i>To Motion</i>	9
10.	<i>To Transportation</i>	3
11.	<i>To Waiting</i>	5
Total Question		68

Based on the inquiries presented above, the data processing will proceed with the WAQ method to determine and prioritize which type of waste significantly impacts the inefficiency of the warehousing activities. The outcomes of the calculations are as follows:

Tabel 7. Waste Assessment Calculation Results

Remarks	O	I	D	M	T	P	W
Yj	0,40808	0,39444	0,37599	0,36792	0,41160	0,34401	0,36838
Pj Factor	0,02641	0,02818	0,02521	0,02401	0,01469	0,00960	0,01476
Yj Final	0,01078	0,01111	0,00948	0,00883	0,00605	0,00330	0,00544
Final Result (%)	19,60	20,21	17,24	16,06	10,99	6,01	9,89
Ranking	2	1	3	4	5	7	6

Based on the data processing results using the Waste Assessment Model (WAM), a ranking of wastes in the warehousing flow at PT. XYZ is obtained, arranged from highest to lowest along with their respective percentages.

E. Value Stream Analysis Tools (VALSAT)

In Value Stream Analysis Tools, calculations are carried out by multiplying waste weights is derived from waste assessment percentages with the weighting factors of each tool in the Seven Mapping Tools. The following presents the VALSAT results for the seven types of waste:

Tabel 8. VALSAT Weighting Results

Waste	Weight	PAM	SCRM	PVF	QFM	DAM	DPA	PS
Overproduction	19,60	19,60	58,8	-	19,60	58,80	58,80	-
Inventory	20,21	60,63	181,89	60,63	-	181,89	60,63	20,21
Defect	17,24	17,24	-	-	-	-	-	-
Motion	16,06	144,54	16,06	-	144,54	-	-	-
Transportation	10,99	98,91	-	-	-	-	-	10,99
Overprocessing	6,01	54,09	-	18,03	6,01	-	6,01	-
Waiting	9,89	89,01	89,01	9,89	-	29,67	29,67	-
Total		484,02	345,76	88,55	170,15	270,36	155,11	31,2

Based on the VALSAT ranking, Process Activity Mapping has the highest score with a value of 484,02 and is therefore selected as the primary tool for further analysis. Consequently, a detailed mapping is conducted using Process Activity Mapping (PAM).

F. Process Analysis Mapping (PAM)

Through Process Activity Mapping (PAM), all warehouse activities are identified and classified into five categories: operation, transportation, inspection, storage, and delay. Each activity is then evaluated as Value Added (VA), Necessary Non-Value Added (NNVA), or Non-Value Added (NVA). The following presents a summary of the PAM results:

Tabel 9. Process Activity Mapping (PAM) Accumulation:

No.	Activity Categories	Frequency	Frequency Presentation	Time (minutes)	Time Presentation
1.	Operation (O)	16	37,21%	86	5,26%
2.	Transportation (T)	8	18,60%	76	4,04%
3.	Inspection (I)	13	30,23%	77	4,09%
4.	Storage (S)	2	4,65%	1560	82,93%
5.	Delay (D)	4	9,30%	82	3,67%
	Total	43	100%	1881	3,67%

No.	Activity Type	Frequency	Frequency Presentation	Time (minutes)	Time Presentation
1.	Value Added Activity (VA)	5	11,63%	38	2,02%
2.	Necessary but Non-Value Added Activity (NNVA)	30	69,77%	1736	92,29%
3.	Non-Value Added Activity (NVA)	8	18,60%	107	5,69%
	Total	43	100%	1881	100%

G. Analysis Fishbone Diagram

The following presents a fishbone diagram analysis used to identify the root causes of critical waste at PT. XYZ:

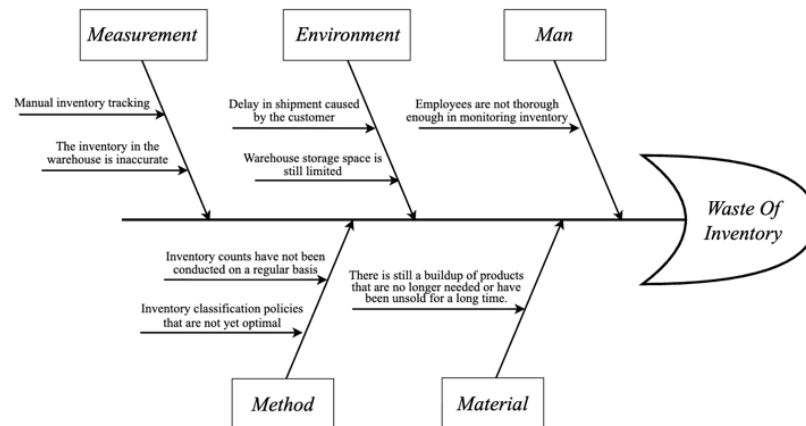


Figure 3. Fishbone Waste of Inventory

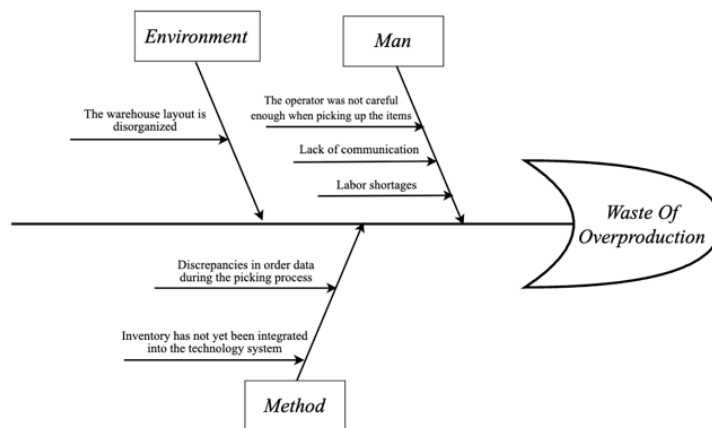


Figure 4. Fishbone Waste of Overproduction

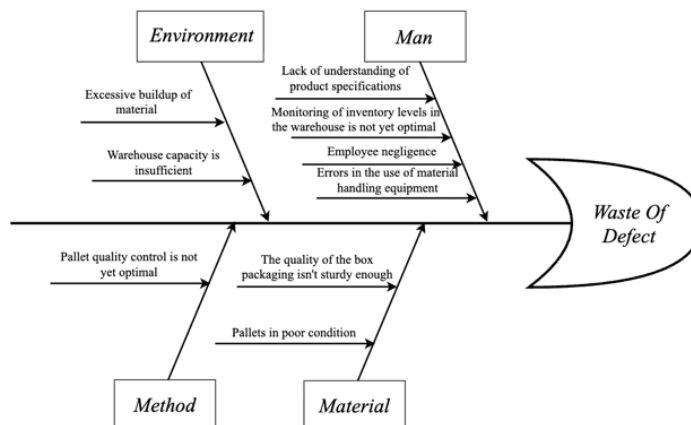


Figure 5. Fishbone Waste of Defect

H. Improvement Analysis Using 5W+1H Method

Based on these causal factors, improvement proposals are developed to reduce or minimize waste and enhance process effectiveness at PT. XYZ:

Tabel 10. 5W+1H Analysis Waste of Inventory

Waste Factor	Waste of Inventory					
	WHAT Waste that occurs	WHY Causes	WHERE Sources of Waste	WHEN Time Occurs	WHO Person in Charge	HOW Suggestions for Improvement
Man	Workers are less careful in controlling inventory	The absence of a technology-based inventory management system such as barcode/scanning leads to high manual activities, thereby increasing workload and potential inaccuracy.	Storage area	At the time of the processing of the goods stored from production	Warehouse Supervisor and Warehouse Admin	Implement an inventory management system based on barcode/RFID scanning and standardize work procedures to improve accuracy and minimize errors.
Material	There is still a buildup of products that are not needed/not sold	Inventory control is not optimal and there is no monitoring of the movement of goods (<i>fast, slow, non-moving</i>) so that there is a build-up of products	Storage area	When the goods are stored for a long time after being produced	Warehouse inventory management operator	Conducting regular stock checks, identifying items that have been stored for a long time, and gradually reducing stock through setting the amount of storage or priority of goods expenditure.
Method	The implementation of <i>stock taking</i> has not been carried out regularly	The lack of a standardized and structured schedule has caused the implementation of <i>stock taking</i> to not run routinely	Storage area	During operational activities, but without regular stock checks.	Warehouse Supervisor and Warehouse Admin	Prepare a regular and structured <i>stock taking</i> schedule, as well as implement a clear stock checking procedure by regularly matching system data and the number of physical goods.
	Inventory classification policies that are not optimal	The inventory classification criteria are not suitable, where the deadline for determining <i>slow moving</i> is too long, causing low movements to be stored in the warehouse for longer.	Storage area	At the time of classifying FSN goods categories during inventory management	Warehouse supervisor	Adjust inventory classification criteria by setting more relevant time limits for the movement of goods, as well as conducting periodic classification evaluations to ensure that the grouping of goods is in accordance with actual conditions.
Environment	Delay in delivery by customer	There is no certainty of delivery schedules from customers and lack of coordination regarding the time of picking up goods.	Storage area	When the goods are produced and ready to be shipped, but there is no definite delivery schedule from the customer	Marketing Division	Set a deadline for picking up goods and apply a progressive <i>fee</i> for goods that are not picked up immediately by the customer, according to the company's policy.
	Warehouse storage area is still limited	The storage capacity of the warehouse is not proportional to the number of goods stored, so storage space is limited.	Storage area	When the number of goods increases and exceeds the storage capacity of the warehouse.	Warehouse supervisor	Optimizing the use of warehouse space through rearrangement of layout, utilization of vertical space (<i>racking system</i>), and addition of storage facilities as needed, according to the company's policy.
Measurement	Manual inventory recording The stock of goods in the warehouse is not yet accurate	Inventory recording that is still done manually without an integrated system causes a mismatch between inventory data and physical conditions in the warehouse.	Item recording and storage area	During the process of receiving and recording the number of finished goods	Warehouse Supervisor and Warehouse Admin	Implement a technology-based inventory recording system (<i>barcode/scanning</i>) to ensure the compatibility between system data and physical conditions in <i>real-time</i> .

Tabel 11. 5W+1H Analysis Waste of Overproduction

Waste Factor	Waste of Overproduction					
	WHAT Waste that occurs	WHY Causes	WHERE Sources of Waste	WHEN Time Occurs	WHO Person in Charge	HOW Suggestions for Improvement
Man	Operators are less careful when picking up goods	Operator negligence in reading and understanding the number of orders, resulting in the collection of goods exceeding the needs.	Picking area in the warehouse.	During the process of picking up goods for delivery needs.	Warehouse supervisor.	Increase operator accuracy through training and <i>briefing</i> , as well as implement procedures for checking the number of goods before the loading process.
	Lack of communication	The submission of order information to the operator is not clear regarding information on the number of goods needed	Picking and loading process area	During the process of picking up goods from the storage and loading of the goods order	Warehouse supervisor.	Convey <i>order information</i> directly from the admin to the operator accompanied by an explanation of the quantity and type of goods, as well as reconfirmation before the <i>picking process</i> .
	Labor limitations	There is no planning for labor needs that are in accordance with the operational conditions of the warehouse.	Picking and loading process area	At a time when the volume of work increases with a limited number of workers.	Warehouse supervisor.	Adjusting the division of labor and scheduling of labor so that the workload is more balanced and the operational process runs more optimally.
Method	Inconsistency of order data in the picking process of goods	The use of order documents that still use manuals and lack of operator accuracy	Area picking order	During the process of picking up goods based on order data.	Warehouse supervisor.	Optimize the use of the system so that order data can be accessed directly by the operator without printing documents, so that the number of items taken corresponds to the quantity ordered.
	Inventory has not been integrated into the technology system	There has not been an integrated technology system in inventory management, so inventory recording is still done manually.	Warehouse storage area	During the process of receiving goods from production to storage of goods	Warehouse Supervisor and Warehouse Admin	Optimize the use of available systems to integrate inventory data in <i>real-time</i> for more accurate inventory recording and monitoring.
Environment	Unorganized warehouse layout	Excessive accumulation of goods in the storage area leads to limited space, so the arrangement of the	Warehouse storage area	At the time of moving goods from production to warehouse	Warehouse supervisor.	Implementing a zoning system by dividing warehouse areas based on the level of movement of goods (<i>fast moving, slow moving, and non-</i>

Waste Factor	Waste of Overproduction					
	WHAT Waste that occurs	WHY Causes	WHERE Sources of Waste	WHEN Time Occurs	WHO Person in Charge	HOW Suggestions for Improvement
		warehouse layout cannot be carried out in an organized manner.				moving), making it easier to arrange storage and access to pick up goods.

Table 12. 5W+1H Analysis Waste of Defect

Waste Factor	Waste of Defect					
	WHAT Waste that occurs	WHY Causes	WHERE Sources of Waste	WHEN Time Occurs	WHO Person in Charge	HOW Suggestions for Improvement
Man	Lack of understanding of product specifications	The high variety of products and limited specification information due to the lack of adequate training or explanation related to product characteristics and handling.	Moving area	During the process of moving from production to warehouse and during <i>order processing</i>	Warehouse supervisor.	Provide training related to product specifications and appropriate handling, accompanied by work guidelines so that operators understand the characteristics of each product.
	Monitoring the condition of old inventory in the warehouse is not optimal	There are still items that are stored for a long period of time without movement, so there is the potential to experience a decrease in quality	Storage Area	During the process of storing and controlling the inventory of goods	Warehouse supervisor.	Monitor inventory conditions periodically and provide markings on goods that have been stored for a long time to facilitate supervision.
	Employee negligence	Lack of thoroughness and discipline of workers in carrying out operational processes.	Warehouse operational area	During the process of arranging goods (transfer, storage and processing)	Warehouse supervisor.	Improve the discipline and accuracy of workers through supervision and clear work directions in the implementation of operations.
	Material handling error	Lack of understanding and skill of operators in using <i>material handling tools</i>	Moving and storage areas.	During the process of moving goods, material handling tools are used.	Warehouse supervisor.	Provide training on the use of <i>material handling</i> tools and ensure operators use tools according to established procedures.
Material	The quality of the box packaging is not strong enough	The specifications of the box packaging material used are not in accordance with the load and characteristics of the product.	Warehouse packaging and storage area	During the process of storing, stacking, or moving goods.	Warehouse supervisor.	Using a box with stronger specifications and adding a corner guard to increase resistance to pressure and impact.
	Less suitable pallet conditions	Lack of supervision and monitoring of the condition of the <i>pallets</i> used	Goods stacking and storage areas	During the process of using <i>pallets</i> in the process of storing goods	Warehouse supervisor.	Periodically check the condition of the <i>pallet</i> and replace <i>pallets</i> that are damaged or unsuitable for use.
Method	Pallet quality control is not optimal	There are no clear standards and procedures for pallet quality control, so that unsuitable pallets are still used in operations.	Goods stacking and storage areas	During the process of using <i>pallets</i> in the process of storing goods	Warehouse supervisor.	Establish pallet eligibility criteria, check the condition before use, and separate damaged <i>pallets</i> to be replaced or repaired so that they are not reused in operations.
Environment	Excessive material build-up	There is still a buildup of products that exceed the load resistance limit causing the array to become unstable	Warehouse storage area	At the time of storage of goods	Warehouse supervisor.	Adjusts stack limits based on material weight and provides visual marking to ensure loads don't exceed capacity.
	Insufficient warehouse capacity	Insufficient warehouse capacity causes some goods to be stored outside the warehouse area, so they have the potential to be damaged and become <i>defective</i> .	Warehouse storage area	At the time of storage of goods	Warehouse supervisor.	Optimize warehouse capacity through layout rearrangement and vertical space utilization, as well as limiting storage outside the warehouse area.

I. Future Value Stream Mapping

In Future State Value Stream Mapping (FSVSM), once improvement proposals are established, activities are streamlined to enhance efficiency by eliminating NVA and reducing NNVA. The following presents the adjusted time for warehouse operational processes at PT. XYZ, as shown in the Figure 6:

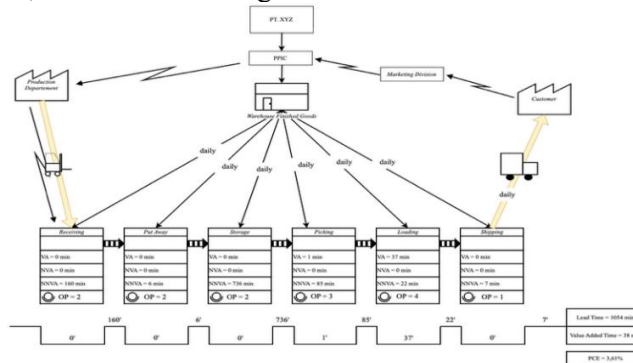


Figure 6. Future Value Stream Mapping (CVSM)

After the proposed improvements were implemented, a calculation was carried out on the efficiency of warehousing activities at PT. XYZ to find out the time efficiency improvement. Here is the calculation:

$$\begin{aligned} \text{Process Cycle Efficiency (PCE)} &= \frac{\text{Value Added}}{\text{Lead time}} \times 100\% \\ &= \frac{38}{1054} \times 100\% = 3,61\% \end{aligned}$$

Based on the calculation results, the proposed improvements increase warehousing efficiency by 1,59%, indicating a reduction in non-value-added activities and a more efficient process, along with simpler FSVSM and process activity mapping aligned with expected conditions.

The enhancements designed to reduce waste are anticipated to influence the outcomes of Process Activity Mapping (PAM), where simplification occurs based on expected results following implementation. Below is a comparison of the situation before and after the suggested improvements at Table 13 below:

Table 13. Comparison of Frequency and Time of Activity Before and After Improvements

No.	Activity Categories	Frequency Before	Frequency After	Time Before (minutes)	Time After (minutes)
1.	Operation (O)	16	13	86	63
2.	Transportation (T)	8	7	76	74
3.	Inspection (I)	13	13	77	77
4.	Storage (S)	2	2	1560	840
5.	Delay (D)	4	0	82	0
	Total	43	35	1881	1054

No.	Activity Type	Frequency Before	Frekuensi After	Time Before (minutes)	Time After (minutes)
1.	Value Added Activity (VA)	5	5	38	38
2.	Necessary but Non-Value Added Activity (NNVA)	30	30	1736	1016
3.	Non-Value Added Activity (NVA)	8	0	107	0
	Total	43	35	1881	1054

After simplification, the number of activities decreased from 43 to 35, reducing 8 activities. Warehouse operational time dropped from 1.881 minutes to 1.054 minutes. Non-Value Added (NVA) activities were completely eliminated (from 107 minutes to 0), while Necessary Non-Value Added (NNVA) time was reduced from 1.736 minutes to 1.016 minutes. These improvements significantly reduce lead time and enhance overall warehouse efficiency.

IV. Conclusion

The study conducted at PT. XYZ identified three primary types of waste in the warehousing process: inventory waste (20,21%), overproduction waste (19,60%), and defect waste (17,24%). Using Value Stream Mapping (VSM), Value Stream Analysis Tools (VALSAT), and Process Activity Mapping (PAM), it was found that the total lead time is 1.881 minutes, with only 38 minutes categorized as Value Added Activity (VA). The primary sources of waste were identified using a fishbone diagram, and suggestions for improvement were outlined through a 5W+1H analysis aimed at waste elimination. These recommendations include adopting a real-time barcode/RFID system, standardizing procedures, reorganizing warehouse zones, setting limits on storage duration, and conducting regular inventory checks. Following the implementation of these improvement suggestions, Future Value Stream Mapping showed a reduction in lead time by 827

minutes, decreasing from 1.881 minutes to 1.054 minutes. Furthermore, the Process Cycle Efficiency (PCE) increased by 1,59%, rising from 2,02% to 3,61%.

References

- [1] N. A. P. Pangestu, J. Parung, and E. Wibisono, "Penerapan Teknologi Industri 4.0 Dalam Lean Warehousing: Literature Review," *J. Ilm. Tek. Ind.*, vol. 12, no. 2, pp. 79–90, 2024, doi: 10.24912/jitiuntar.v12i2.31009.
- [2] A. B. Maulana, D. Ernawati, and S. Dewi, "Implementation Lean Warehousing Using Waste Assessment Model (WAM) Method," *J. La Multiapp*, vol. 6, no. 3, pp. 689–700, 2025, doi: 10.37899/journallamultiapp.v6i3.1972.
- [3] R. Setiawan, N. P. Sugihartanti, and M. I. Ibadurrahman, "Sistem Manajemen Gudang Bebas Web dengan Teknologi Barcode Scanner pada Industri Manufaktur : Sebuah Kajian Literatur Web-based Warehouse Management System using Barcode Scanner Technology in Manufacturing Industries : A Literature Review," *Integr. J. Ilm. Tek. Ind.*, vol. 09, no. 02, pp. 124–135, 2024.
- [4] M. R. Hidayat, R. Y. Prasetyo, A. R. Dillah, S. Sahara, U. Negeri, and J. Abstract, "Mengelola Adminitrasi Pergudangan Di Dalam Pelabuhan Tanjung Priok," *J. Ilm. Wahana Pendidik.*, vol. 9, no. 15, pp. 1–9, 2023.
- [5] D. A. de J. Pacheco, D. M. Clausen, and J. Bumann, "A multi-method approach for reducing operational wastes in distribution warehouses," *Int. J. Prod. Econ.*, vol. 256, no. December, 2023, doi: 10.1016/j.ijpe.2022.108705.
- [6] I. Widowati, F. Y. Sari, and Sutardjo, "Proses Aliran Raw Material Di Departemen Warehouse Raw Material PT. Samcon Indonesia," *J. Teknol.*, vol. 12, no. 1, pp. 1–10, 2022, [Online]. Available: <https://jurnal.wastukancana.ac.id/index.php/teknologika/article/view/148>
- [7] A. L. Pratiwi and E. P. Widjajati, "Analisis Pemborosan Pada Proses Aliran Pergudangan PT. FLSmidth Indonesia dengan Metode Lean Warehousing," *J. Tek. Mesin, Ind. Elektro dan Inform.*, vol. 2, no. 4, pp. 124–135, 2023, doi: 10.55606/jtmei.v2i4.2993.
- [8] A. Naziihah, J. Arifin, and B. Nugraha, "Identifikasi Waste Menggunakan Waste Assessment Model (WAM) di Warehouse Raw Material PT. XYZ," *J. Media Tek. dan Sist. Ind.*, vol. 6, no. 1, p. 30, 2022, doi: 10.35194/jmtsi.v6i1.1599.
- [9] N. G. Ibrahim and Y. Prasetyawan, "Evaluasi Pergudangan dengan Pendekatan Lean Warehousing dan Linear Programming (Studi Kasus PT. X)," *J. Tek. ITS*, vol. 9, no. 2, pp. 278–283, 2021, doi: 10.12962/j23373539.v9i2.55529.
- [10] A. Ma'sum and W. Setiafindari, "Analisis Pemborosan Pada Proses Produksi Dengan Metode Value Stream Mapping Di PT Mandiri Jogja Internasional," *J. Cakrawala Ilm.*, vol. 1, no. 10, pp. 117–126, 2022, doi: <https://doi.org/10.53625/jcijurnalcakrawalailmiah.v1i10.2582>.
- [11] M. Zaenal, Dr. Novi Marlayana, and Dr. Andre Sugiono, "Analisis Penerapan Lean Manufacturing dengan Metode Valsat untuk Memaksimalkan Produktivitas pada Proses Operasi Crusher (Studikasu di PT Semen Gresik Pabrik Rembang)," *Konstelasi Ilm. Mhs. UNISSULA 5*, vol. 5, no. Kimu 5, pp. 1–20, 2021, [Online]. Available: <https://jurnal.unissula.ac.id/index.php/kimueng/article/view/17882/6025>
- [12] M. Herlingga, "Analisis Penerapan Lean Manufaktur Untuk Mengurangi Pemborosan Di Lantai Produksi PT E Purwakarta Tahun 2021," *J. Ind. Manag. Entrep.*, vol. 01, no. 1, pp. 98–105, 2023, [Online]. Available: <https://ojs.polbap.ac.id/ojs/index.php/jime/>
- [13] T. B. Febrianty, F. A. Hermansyah, I. A. S. Syafiin, and M. Fauzi, "Identifikasi Jenis Pemborosan Yang Terjadi Pada PT.PQR Dengan Menggunakan Metode 8 Waste," *J. Ilm. Tek. dan Manaj. Ind.*, vol. 2, no. 1, pp. 94–101, 2022, doi:

- 10.46306/tgc.v2i1.28.
- [14] V. Gaspersz, *Lean Six Sigma for Manufacturing and Service Industries*. Jakarta, 2007. [Online]. Available: <https://books.google.com/books?id=-APoYfWmr7AC>
- [15] L. C. Anam and D. D. Nurkertamanda, "Penerapan Lean Manufacturing Di CV. Lumbung Tani Redjeki (LTR) Untuk Meningkatkan Proses Produksi," *E-Journal Undip*, 2024, doi: 10.1787/f945a7f8-he.
- [16] B. D. Novitasari and R. Rochmoeljati, "Implementasi Value Stream Mapping dan Value Stream Analysis Untuk Meminimalisir Pemborosan Waktu Pendistribusian di PT. Nur Jaya Energi," *Juminten*, vol. 2, no. 6, pp. 132–143, 2021, doi: 10.33005/juminten.v2i6.336.
- [17] P. Hines and N. Rich, *The Lean Enterprise : Designing and Managing Strategy Processes for customer-winning performance*. American Management Association, 1997. doi: 10.1108/01443579710157989.
- [18] Suparno and A. S. Susanto, "Peningkatan Produktivitas Leaf Spring Jenis Minicup Tipe MMS 2230 dengan Mengurangi Pemborosan Proses Produksi Melalui Penerapan Metode Lean Manufacturing," *J. Rekayasa Sist. Ind.*, vol. 10, no. 1, pp. 89–100, 2021, doi: 10.26593/jrsi.v10i1.3813.89-100.
- [19] W. I. Putra and E. P. Widjajati, "Penerapan Metode Lean Warehousing dalam Analisis Pemborosan pada Proses Aliran Pergudangan," vol. 09, no. 02, pp. 861–871, 2025, doi: 10.33087/ekonomis.v9i2.1971.
- [20] D. A. Zulkifli, B. Hanum, and D. Junaedi, *Metode Penelitian Teknik Industri*. PT. Sumber Alam Langgeng Barakah (Sumalaba), 2022. [Online]. Available: <https://books.google.com/books?id=GMJrEQAAQBAJ>
- [21] I. A. Rawabdeh, "A model for the assessment of waste in job shop environments," *Int. J. Oper. Prod. Manag.*, vol. 25, no. 8, pp. 800–822, 2005, doi: 10.1108/01443570510608619.
- [22] Q. Nurlaila, R. I. Yuniawati, L. Susanti, and A. Cahyati, *LEAN MANUFACTURING*. Makassar: CV. Tohar Media, 2023.
- [23] E. Fanany, A. Gusta, and Y. P. Negoro, "Analisis Waste pada Proses Distribusi Menggunakan Metode Lean Distribution Guna Mengurangi Keterlambatan Distribusi Hose Industri," vol. 5, no. 1, pp. 163–173, 2026.