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Analysis of Finished Product Warehouse Activity Flow Using Lean Warehouse Method

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Abstract— This company is a light steel processing manufacturing company that specializes in the production of hollow structural sections. A warehouse is the main component that enables a company's operational functions. The role of the warehouse is not only focused on storage and distribution but also on operational efficiency which can have an impact on business competitiveness. Warehousing activities at this company ain't been optimal due to waste. Waste that occurs such as searching for empty areas for storage, waiting time for the next process, repeated product inspections, has an impact on the flow of warehousing activities. This study seeks to assess the amount of waste and provide recommendations to minimize waste within the finished product warehousing operations at this company. This study uses the Lean Warehousing method consisting of Value Stream Mapping, Process Activity Mapping, and 5 Whys Analysis. The results of this study identify 4 wasteful activities with the highest time such as waiting for the customer's cargo truck to pick up products (I10), moving products to the truck loading bed (C5), moving products from the production floor to the storage area (S5), waiting for the next process in order to move products (P2). The proposed improvements can reduce 8 non-value-added activities and trim activity time by 1015 minutes. The suggested improvements also increase Process Cycle Efficiency by 15.32% from 11.17% to 26.49%. This proves that the implementation of lean warehouse can improve efficiency and service quality as a whole.

Keywords—5 Whys, Lean Warehouse, Process Activity Mapping, Process Cycle Efficiency, Visual Stream Mapping, Waste

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I. INTRODUCTION

The existing competitions in manufacturing industries are becoming apparent in the warehousing operations, whether as third-party logistics or entire supply chain [1], where a lean approach is utilized to enhance productivity [2][3]. In the manufacturing industry, the role of the warehouse is not only focused on storage and distribution but also on operational efficiency which can have an impact on business competitiveness [4]. To remain competitive in a dynamic market, companies need to implement strategies to

optimize the production process by eliminating non-value-added activities. Therefore, the lean warehouse approach is widely applied to improve operational efficiency [5].

This company is a light steel product manufacturing company, specializing in the production of hollow structural sections. After going through a series of production processes, the hollow will then be stored in the finished product warehouse. Warehousing activities at this company ain't been optimal due to waste. Waste that occurs such as searching for empty areas for storage, waiting time for the next process, repeated product inspections, has an impact on the flow of warehousing activities. If this problem is left untreated, it will certainly have a detrimental impact on the company such as bottleneck which can increase risks and increase warehouse operational costs.

Based on these problems, this study seeks to assess the amount of waste and provide recommendations to minimize waste within the finished product warehousing operations at this company using Lean Warehouse method. This study's findings are anticipated to help businesses spot inefficiencies within their warehousing operations and to make improvement that can significantly increase operational efficiency and service quality.

II. RELATED WORKS

A. Warehouse

Warehouses serve as temporary locations for storing and retrieving inventory that supports subsequent operations, either for distribution or for end consumers [6]. In addition to being a place for storage and improving service levels, warehouses also have other functions such: as a buffer against changing conditions and market uncertainty, supporting just-in-time systems, and becoming a place to carry out activities that add value. A warehouse management system is a core component within the supply chain. Its primary purpose is to oversee and manage all operations happening inside such as shipping, product receiving, putting away, moving, and picking [7].

B. Lean Warehouse

Lean focuses on continuous improvements, aiming to eliminate waste and increase the value of products, providing value to its customers. The purpose of implementing lean is to increase productivity, improve quality, increase the ability to gain profit and increase market competitiveness. The basic concept of lean is to eliminate or reduce waste [8]. Lean warehouse is a principle that demands continuous, systematic, and measurable improvement in the warehousing process, involving the full participation of all employees. The main focus of a lean warehouse is on fulfilling order requests efficiently, by minimizing all non-value-added activities in warehouse operations such as product receiving, storing, taking orders, packing, and shipping [9].

C. Waste

Waste is any activity that does not add value to the products or services offered by the company from the customer's perspective. If a company wants to implement a lean warehouse, it is important to minimize activities that do not add value, and identify the sources of waste. Waste generally consists of 9 types, namely overproduction, unnecessary inventory, transportation, waiting time, product defects, unnecessary movement, excess processing, non-utilizing employees, and environmental, health, safety (EHS) [10].

D. Value Stream Mapping

Value stream mapping is a method employed to examine and describe the flow of value in a business process, from the initial stage to the final stage. The purpose of this mapping is to identify various types of waste that exist along the value stream and take action to eliminate such waste [10]. Value stream mapping can be developed by creating

a current state map and future state map. The current state map is compiled to describe the actual conditions on the production floor, which functions to detect waste and its sources. The future state map reflects the company's future conditions as a proposed design for improvements to the current condition map [11]. In value stream mapping, process cycle efficiency (PCE) defined as the ratio of the value-added time to total lead time, will be calculated with the following formula:

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

Where PCE is process cycle efficiency, VA is value added activity, $\sum t$ is lead time [12].

E. Process Activity Mapping

Process activity mapping is one of the VSM tools that's useful for detecting wasteful activities [13]. Process activity mapping includes physical and information flows, the duration required for each activity, the distance traveled, and the level of product inventory at various stages of production [14]. This tool's basic idea is to chart every step in a process, including operations, transportation, inspection, delay, and storage, then grouped into existing activity types starting from value-adding activities, necessary non-value-adding activities, and non-value-adding activities [15].

F. 5 Whys Analysis

5 Whys Analysis is a method to evaluate and identify factors that cause failure in a process [16]. 5 Whys Analysis is used to investigate the root cause of an issue. This method is one component of Root Cause Analysis [17]. The purpose of implementing the 5 Whys system is to make it easier to find the root cause by repeating questions that begin with the word "why" five times, each answer to the question consecutively provides information on symptom, excuse, blame, cause, root cause [18].

III. METHOD

The methods used to collect data in this study are interviews and observations. The data that has been collected will be processed using Value Stream Mapping and Process Activity Mapping to identify the level of waste so that the identification of activities and waste weights is obtained. The cause of waste identification uses the Root Cause Analysis method, namely 5 Whys Analysis. Based on the identification of the root causes of waste, a proposal for improvement is formulated to increase the efficiency of the flow of finished product warehousing activities. The reason for employing the method is that warehouse intricacies can be explored and resolved both quantitatively and qualitatively [19][20].

IV. RESULT AND DISCUSSION

A. Research Data Collection

The primary data required in this study are the warehouse flow process and the time of the warehouse flow process. These activities will be classified into 3 types, namely value-added activity (VA), necessary non-value-added activity (NNVA), and non-value-added activity (NVA).

Table 1.
Warehouse Activity Flow Process

Code	Activity	Time (minutes)	VA	NNVA	NVA
Product Receiving					
P1	Receive finished product information from PPIC	6		V	

Code	Activity	Time (minutes)	VA	NNVA	NVA
P2	Check the condition of products on production floor	12		V	
P3	Validate finished products in the stock control database	10	V		
Storage					
S1	Wait for the next process in order to move products	18			V
S2	Find empty places for product storage	5	V		
S3	Prepare empty places for product storage	5			V
S4	Prepare hoist crane	7		V	
S5	Move products from production floor to storage area	48		V	
S6	Store products in the warehouse	15		V	
S7	Label based on product type with paint	12	V		
S8	Record product type and quantity on stock cards	8	V		
S9	Input stock card data into the stock control database	7	V		
S10	Place stock cards on storage shelves	5		V	
Issuing					
I1	Confirm purchasing orders	6	V		
I2	Check the items requested in the stock control database	5	V		
I3	Find storage locations for requested items	7			V
I4	Prepare shelves for temporary storage of customer orders	5			V
I5	Prepare hoist crane	7		V	
I6	Move products from storage to customer shelves	95	V		
I7	Store customers ordered items on shelves	15	V		
I8	Reduce the number of products on stock cards	3		V	
I9	Notify customer that the orders are ready for pick up	11	V		
I10	Waiting for the customer’s cargo truck to pick up	1290			V
I11	The truck arrives and the driver parks at the security post	10			V
I12	The driver goes to warehouse to submit pick up memo	4			V
I13	Check conformity of purchase order data with pick up memo	3	V		
I14	Print the delivery note	7	V		
I15	The driver submits delivery note to the security post	5		V	
I16	The security directs the driver to loading area	3		V	
Customer Pick Up					
C1	The driver parks in loading area and opens loading door	8			V
C2	Check conformity of product to be loaded with delivery note	7	V		
C3	Product check by quality control	5	V		
C4	Prepare hoist crane	7		V	
C5	Product is moved to the truck-loading bed	75		V	
C6	The driver checks conformity of quantity and product items	5		V	
C7	The driver closes the loading door	9			V
C8	Input status “product loaded” into the stock control database	5		V	

B. Current Value Stream Mapping

Initial mapping using Current Value Stream Mapping was conducted to show the flow of processes, information, and materials in operational activities in the warehouse. The results of mapping using Current Value Stream Mapping will be used as a reference to identify waste that occurs in each activity or process carried out in the warehouse.

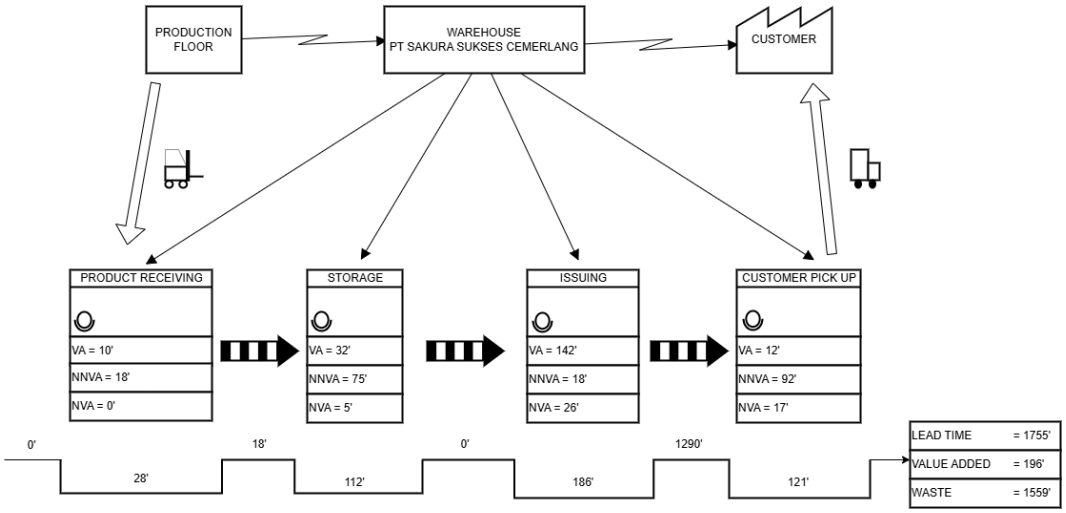

Figure 1. Current Visual Stream Mapping

Based on Figure 1, the Process Cycle Efficiency value is 11.17%, which means that the flow of the warehouse is still not running optimally. This happens because there is still waste that occurs so further identification must be carried out to obtain the cause of the waste.

C. Process Activity Mapping

Process Activity Mapping is used to identify operational activities in more detail by grouping activities into five types, namely Operations (O), Transportation (T), Inspection (I), Storage (S), and Delay (D). The following is a summary table of the Process Activity Mapping result.

Table 2.
Summary of Process Activity Mapping

Description	Total Activity	Total Time	Percentage Activity	Percentage Time
Activity Categories				
VA	14	196	37,84%	11,17%
NNVA	14	203	37,84%	11,57%
NVA	9	1356	24,32%	77,26%
Activity Type				
O	24	162	64,86%	9,23%
T	3	218	8,11%	12,42%
I	6	37	16,22%	2,11%
S	2	30	5,41%	1,71%
D	2	1308	5,41%	74,53%

D. Determination of Critical Waste

Determination critical waste is done by sorting activities from the highest to the lowest time, with the following results.

Table 3.
Critical Waste Ranking

Rank	Code	Activity	Time (minutes)
1	I10	Waiting for the customer's cargo truck to pick up	1290
2	C5	Product is moved to the truck-loading bed	75
3	S5	Move products from production floor to storage area	48
4	S1	Wait for the next process in order to move products	18
5	S6	Store products in the warehouse	15

Rank	Code	Activity	Time (minutes)
6	P2	Check the condition of products on production floor	12
7	I11	The truck arrives and the driver parks at the security post	10
8	C7	The driver closes the loading door	9
9	C1	The driver parks in loading area and opens loading door	8
10	S4	Prepare hoist crane	7
11	I3	Find storage locations for requested items	7
12	I5	Prepare hoist crane	7
13	C4	Prepare hoist crane	7
14	P1	Receive finished product information from PPIC	6
15	S3	Prepare empty places for product storage	5
16	S10	Place stock cards on storage shelves	5
17	I4	Prepare shelves for temporary storage of customer orders	5
18	I15	The driver submits delivery note to the security post	5
19	C6	The driver checks conformity of quantity and product items	5
20	C8	Input status “product loaded” into the stock control database	5
21	I12	The driver goes to warehouse to submit pick up memo	4
22	I8	Reduce the number of products on stock cards	3
23	I16	The security directs the driver to loading area	3

The results of critical waste ranking, where the 4 most frequent waste activity are Waiting for the customer’s cargo truck to pick up (I10), Product is moved to the truck-loading bed (C5), Move products from production floor to storage area (S5), and Wait for the next process in order to move products (S1). These 4-waste activity will be further identified to find out the causes and proposed improvements.

E. Identify Root Cause of Waste Using 5 Whys Analysis

5 Whys Analysis is used to identify the root cause of waste in the warehouse flow process so that recommendations for improvement can be determined. The following are the causes of four wastes with the highest time using the 5 Whys Analysis.

Table 4.
5 Whys Analysis

Code	Activity	Why 1	Why 2	Why 3	Why 4	Why 5
I10	Waiting for the customer’s cargo truck to pick up	The customer's cargo truck doesn’t arrive on time according to the pick-up schedule.	Customers haven’t confirmed the exact pick-up schedule and are changing the schedule suddenly	Unclear communication between the company and customers regarding pick-up schedules	The company relies on manual agreements without any SOPs that regulate confirmation mechanisms and schedule changes.	No policy ensures regularity and transparency in coordinating product retrieval
C5	Product is moved to the truck-loading bed	The process of lifting and placing products into the truck is slow.	Operators need to make some adjustments when moving products to the truck bed.	There is a mismatch between product positions on shelves and the required positions in the truck bed	Temporary product shelf arrangement does not fully consider efficient loading sequences	No standard regulates the adjustment of product arrangement patterns
S5	Move products from production floor to storage area	The process of lifting, moving, and placing products is slow.	There is a waiting period before the crane starts lifting products from the production	Operators wait for products to be stacked or wait for transfer instruction	No schedule or automation system ensures product readiness for immediate transfer	A digital system has not been implemented to reduce delays in transfers.

Code	Activity	Why 1	Why 2	Why 3	Why 4	Why 5
			floor.			
S1	Wait for the next process in order to move products	The operator does not immediately carry out the transfer without instructions.	There is no standard procedure or system that schedules product transfers	Workflow planning is not systematically documented	No evaluation of internal logistics and distribution activities	The company has not prioritized increasing efficiency in goods transfer activities

F. Proposed Improvements

The proposed improvements given to eliminate the occurrence of waste with the highest time are based on the results of identification and analysis that have been done previously. The following is a summary table of proposed improvements.

Table 5.
Summary of Proposed Improvements

Code	Activity	Proposed Improvement
I10	Waiting for the customer's cargo truck to pick up	Implement clear SOPs regarding confirmation of pick-up schedules and consequences of delays.
		Provide internal cargo truck buffers as an alternative if customers are late in picking up products.
C5	Product is moved to the truck-loading bed	Optimize product arrangement on customer temporary shelves to match the loading sequence into the truck bed.
		Review the layout of the customer's temporary shelf area so that the crane can move products with minimal position adjustments.
S5	Move products from production floor to storage area	Synchronize production and transfers with a fixed schedule so that finished products are ready to be lifted without waiting for manual instructions.
		Optimize the layout in the hollow area so that product transfers are efficient.
S1	Wait for the next process in order to move products	Use a simple Warehouse Management System (WMS) or visual board (kanban board) that shows product status.
		Set a fixed time interval for product transfers so that operators do not have to wait for instructions.

G. Simplification of Process Activity Mapping

The proposed improvements that have been given to eliminate the waste that occurs will affect the Process Activity Mapping results. Process Activity Mapping simplification is carried out based on the predicted results after the application or implementation of the proposed improvements given. The following is a summary of comparison of Process Activity Mapping before and after the proposed improvements.

Table 6.
Process Activity Mapping Comparison Results Before and After Proposed Improvements.

Description	Total Activity	Total Time	Percentage Activity	Percentage Time
Before Proposed Improvements				
Activity Categories				
VA	14	196	37,84%	11,17%
NNVA	14	203	37,84%	11,57%
NVA	9	1356	24,32%	77,26%
Activity Type				
O	24	162	64,86%	9,23%
T	3	218	8,11%	12,42%
I	6	37	16,22%	2,11%
S	2	30	5,41%	1,71%

D	2	1308	5,41%	74,53%
After Proposed Improvements				
Activity Categories				
VA	14	48,28%	196	26,49%
NNVA	14	48,28%	184	24,86%
NVA	1	3,45%	360	48,65%
Activity Type				
O	17	58,62%	102	13,78%
T	3	10,34%	218	29,46%
I	6	20,69%	30	4,05%
S	2	6,90%	30	4,05%
D	1	3,45%	360	48,65%

H. Future Value Stream Mapping

Future value stream mapping is used to map warehouse process flow after the proposed improvements. Mapping on future value stream mapping produces a Process Cycle Efficiency value of 26.49%, which means an increase of 15.32% from the previous value of 11.17%. This increase indicates an increase in efficiency in the warehousing process after the proposed improvements. Future value stream mapping can be seen in the following figure.

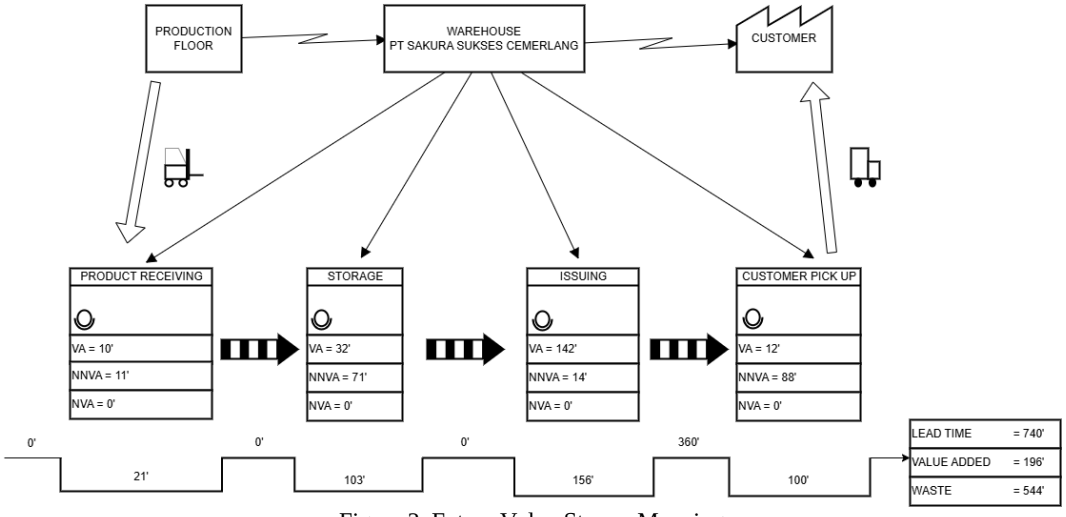

Figure 2. Future Value Stream Mapping

V. CONCLUSION

Based on the results and discussion, 4-waste activity with the highest time in finished product warehousing process, namely Waiting for the customer's cargo truck to pick up (I10) for around 1290 minutes, Product is moved to the truck-loading bed (C5) for around 75 minutes, Move products from production floor to storage area (S5) for around 48 minutes, and Wait for the next process in order to move products (S1) for around 18 minutes. Based on the proposed improvements, several operational activities carried out in finished product warehousing are reduced in time and number of activities. The reduction can reduce 8 activities from 37 activities to 29 activities and reduce activity time by 1015 minutes from 1755 minutes to 740 minutes. The proposed improvement also increases Process Cycle Efficiency (PCE) by 15.32% from 11.17% to 26.49% which means there is an increase in efficiency in the finished product warehousing process after

the proposed improvement, where it helps minimize waste in operational activities in the finished product warehousing if implemented properly and optimally. It is hoped that this research can be used or developed as a main idea for further research related to reducing waste in the finished product warehousing and further research needs to be carried out regarding the costs required to implement each proposed improvement that has been given.

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