WASTE REDUCTION STRATEGY BASED ON *LEAN MANUFACTURING* METHOD IN THE WALL PAINTING INDUSTRY

Lithrone Laricha Salomon[1,2]**, Wilson Kosasih**[1,3]

[1]Universitas Tarumanagara, Letjend S Parman Kav 1, Jakarta, Indonesia
[2]lithrones@ft.untar.ac.id, [3]wilsonk@ft.untar.ac.id

Abstract. Companies are required to be able to produce more effectively and efficiently by increasing productivity and eliminating waste. Various types of waste that occur can be reduced by optimizing production process activities that can provide added value. To produce wall paint, the required time is 169 minutes or 2.82 hours. The production process of this wall paint has a long production time because there is a high amount of waste on the production floor. This study aims to identify and analyze the factors that cause waste so that suggestions can be made to reduce waste in the wall paint production line. This research begins by providing an overview of the actual state of the company in the value stream mapping, followed by identifying the waste that occurs by using the WRM and WAQ (transportation, inventory, and waiting time). The factors causing the occurrence of waste can be identified using a fishbone diagram and five whys analysis so that suggestions for improvement can be given which can reduce the time of non-value-added activity for 96 minutes. The suggestions given can reduce production lead time by 38.82% and increase process cycle efficiency by 16.02%.

Keywords: *Lean Manufacturing, Waste, Process Cycle Efficiency, Value Stream Mapping, WAQ, WRM.*

48. Introduction

The productivity of a company in the manufacturing industry can be seen from the company's ability to carry out the production process effectively and efficiently. Because many raw materials and processes are passed in producing a product, it is often found that waste arises in a production process activity. Based on the lean manufacturing perspective, the waste that usually arises in the production process is known as the seven waste concept, namely overproduction, inventory, waiting, motion, transportation, rework, and overprocessing [1]. Based on all the problems that occur as mentioned above, companies are demanded more in order to meet customer expectations and increase productivity by reducing existing waste [2].

The existence of processes or work activities that are not needed has the result that a series of production processes becomes inefficient. The wall paint producing company that is the subject of this research is a company that has large-scale production (large batch) on a make-to-order and make-to-stock basis. Based on these conditions, it results in additional handling activities that should not be needed which results in waste. One of the significant impacts of the existing problems is the length of time the process of moving goods (which includes the transportation category) from the raw material warehouse to the production floor, from the production floor to the finished goods warehouse, from the finished goods warehouse to the distribution area and vice versa, and accumulation of product inventory in the warehouse. Based on the existing problems, the company needs an improvement strategy to minimize the waste that occurs in the wall paint production line and optimize productivity at the same time [3] with reference to the seven waste concept with a lean manufacturing approach.

49. Research Methodology

The research methodology begins with determining the research topic which is determined based on the background of the problems that occur in the field through an interview process with management and direct observation of the company's condition, especially related to the activity of the wall paint production process accompanied by literature studies as support regarding the use of appropriate methods for research. this.After the problems that occur in the field can be identified, the formulation of the problem can be determined which contains the importance of identifying and analyzing the types of waste, the impact given by waste, and the factors that cause waste to take the right steps in minimizing the types of waste that hinder the process wall paint production Based on the existing problem formulation, the research objectives can be determined, namely to identify the types, impacts, and factors that cause waste that hinder the wall paint production process and provide suggestions for improvements to activities that result in waste.

After the research objectives are determined, the next step is to collect data. The data used for further processing in this study consists of two types, namely primary data obtained directly by conducting interviews with divisions related to production and management and conducting direct observations in the field to obtain data which includes cycle time, number of operator, set-up time, changeover time, raw materials used and other supporting data. The second data is secondary data obtained from the company's historical data including information about the profile and management of the company through the company's data archives. After collecting the data, a data validity test was carried out for the production and delivery process cycle time data, followed by a normality test for the production and delivery process cycle time data. After the data is declared valid and normal, the next step can be carried out, namely calculating the average cycle time for the production and delivery process, then determining the adjustment factor and allowance factor as well as calculating the normal time and standard time for the production and delivery process.

The next step of this research is the creation of a Current Value Stream Mapping so that waste can be identified. Then proceed with conducting a waste analysis using the Waste Relationship Matrix and the Waste Assessment Questionnaire. After the waste analysis has been carried out, activities can be grouped using Process Activity Mapping. For Analysis of Factors Causing Waste Fishbone Diagram and Five Whys Analysis are used. The next step is to make a proposed improvement plan followed by making a Future Value Stream Mapping. The last step of this research methodology is to analyze the results of proposed improvements and provide conclusions and suggestions for the company.

2.1 *Lean Manufacturing*

Please Literally, lean means lean. The word lean was then used in the manufacturing world after recognizing the Toyota Production System (TPS), where the main purpose of using TPS is to consistently increase the efficiency of the manufacturing process and eliminate waste to completion. The seven principles of lean in the book Lean Software Development: An Agile Toolkit are eliminating waste, setting quality standards, providing useful learning, suspending all decisions that are not beneficial, delivering to consumers in the shortest time, respecting colleagues, and optimizing the entire manufacturing process from upstream to downstream [3].

In this study, one of the important principles discussed and further investigated is eliminating waste that hinders the manufacturing process. Thus, lean manufacturing can be interpreted as a methodology that focuses on minimizing the waste that is increasingly occurring in the manufacturing process and maximizing productivity at the same time. In other words, the lean approach focuses on efficiency without reducing process effectiveness including increasing value-added operations, reducing waste, and meeting customer needs [4].

2.2 *Waste*

Literally, the term youth in Japanese or waste in English means waste. The waste in question is all activities or activities in a series of manufacturing processes that do not add value to the company or customers. Seven types of waste, also known as TIMWOOD, can be explained as follows [5].

T – Transportation is a type of waste that is related to the entire movement of raw materials, products, and workers during the manufacturing process to the process of distributing products to customers. I – Inventory is a combination of unprocessed raw materials, semi-finished goods, and excess finished goods which results in a buildup in the warehouse. M – Motion is a type of waste associated with unnecessary movements of people or machines that do not add value to products (goods and/or services) to be distributed to customers, but result in additional costs and time. W – Waiting is a type of waste where raw materials or products are not processed by machines or workers. Vice versa, when machines or workers do not do work. O – Overproduction is a type of waste that produces a product that exceeds customer requirements and/or produces faster than the time required by the customer. O – Overprocessing is a type of waste that carries out unnecessary work processes or activities so that the series of production processes becomes inefficient. D – Defect products are a type of waste where the product cannot be accepted by consumers and is returned to the company for rework or product destruction.

2.3 Value Stream Mapping

Value streams are all activities that provide or do not provide added value that are carried out to process a product with two main streams, namely the production flow starting from purchasing raw materials until the product reaches the customer and the design flow starting from concept planning to realizing implementation [6]. Whereas value stream mapping (VSM) is an important tool that is often used in lean manufacturing implementations as an illustration or static map of a series of processes that can show when a value in the form of information or raw materials is added to a process *flow [7]*.

50. Result and Discussion

Current Value Stream Mapping

The actual situation of all processes from start to finish that occur in the company is then described in the current value stream mapping which can be seen in Figure 1.
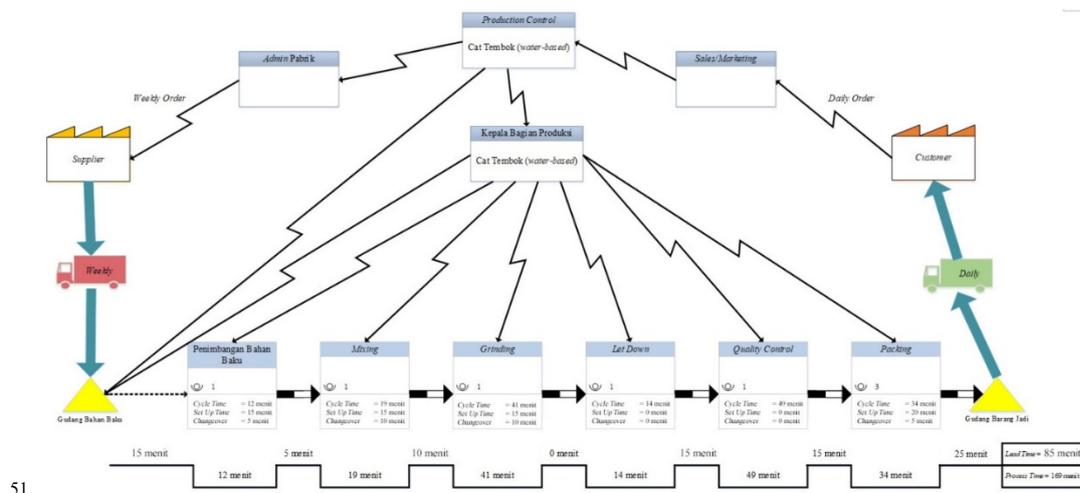

51.

Figure 1. Current Value Stream Mapping

3.2. Waste Relationship Matrix

The WRM questionnaire consists of several questions that must be answered based on the actual situation that occurs in the field. This questionnaire was also proposed to find out the relationship or connection between the 31 relationships [8] that exist between each waste (seven waste). Filling in the 31 WRM questionnaires was carried out by the Head of Factory, Head of Production Department, and Head of QC. The score obtained from the results of the questionnaire is converted into a matrix of relationships between waste in the form of waste relationship values which can be seen in Table 1.

Table 1. Waste Relationship Value

F/T	O	I	D	M	T	P	W	Total	% Total
O	10	6	2	2	2	0	6	28	14,894
I	2	10	2	4	8	0	0	26	13,830
D	2	6	10	2	2	0	4	26	13,830
M	0	2	2	10	0	2	8	24	12,766
T	2	2	2	10	10	0	10	36	19,149
P	2	2	2	4	0	10	6	26	13,830
W	2	8	2	0	0	0	10	22	11,702
Total	20	36	22	32	22	12	44	188	
% Total	10,638	19,149	11,702	17,021	11,702	6,383	23,404		100

From Table 1 above, it can be concluded that the value from transportation has the largest percentage with a value of 19.149%, which means that transportation waste has a large enough influence to cause other wastes, and the value of to waiting has the largest percentage with a value of 23.404%, which means that waiting is a waste which is most often generated by other wastage.

3.3. Waste Assessment Questionnaire

After distributing the questionnaires to several predetermined related parties, the next step is to conduct interviews with the same three respondents to answer the waste assessment questionnaire (WAQ) divided into two types (from and to) which are also grouped into four categories, namely man, materials, machines, and methods. Each question on the WAQ is assessed by choosing between three answer options with a weight of 1 each; 0.5; and 0. The weighting calculation from the results of the waste assessment questionnaire is then processed and recapitulated into Table 2.

Thus, from the recapitulation results above, it can be concluded that the type of waste that occupies the three highest ranks is transportation with a value of 20.18%, followed by inventory with a value of 18.29% and waiting with a value of 15.51%.

Table 2. Waste Assessment Questionnaire Analysis Recapitulation

Waste	O	I	D	M	T	P	W	Total

Score (Yj)	0,41	0,34	0,35	0,33	0,44	0,35	0,28	2,5
Pj Factor	158,44	264, 83	161,84	217,29	224,08	88,28	273,88	1123,81
Final Result (Yj Final)	64,82	88,82	56,43	71,02	97,96	31,13	75,30	485,48
Final Result (%)	13,36	18,29	11,62	14,63	20,18	6,41	15,51	100
Rank	5	2	6	4	1	7	3	

3.4 Process Activity Mapping

After describing the manufacturing process into a current value stream mapping, the next step is to describe every activity that occurs on the wall paint production floor into a process activity mapping. Each activity will be divided into five types of activities, namely operation (O), transportation (T), inspection (I), delay (D), and storage (S); then categorized into three categories, namely value added activity (VA), non value added activity (NVA), and necessary but non value added activity (NNVA) which are then grouped based on activity and type which can be seen in Table 3 and Table 4.

Table 3. Grouping by Type of Activity

Activity	Amount	Time (Minute)	Percent (%)
Operation	11	234	61,74
Transportation	6	99	26,12
Inspection	1	3	0,79
Delay	2	12	3,17
Storage	1	31	8,18
Total	21	379	100

Table 4. Grouping Based on Activity Value

Activity Point	Amount	Time (Minute)	Percent (%)
Value Added	7	179	47,23
Necessary but Non Value Added	12	188	49,60
Non Value Added	2	12	3,17
Total	21	379	100

From the current value stream mapping depicted in Figure 2 and the grouping of activities based on their type and value in Table 3 and Table 4 above, it is obtained that the percentage of activities that provide added value to the product or what is called a process cycle efficiency is 47.23% with a time of 179 minutes.

3.5. Analysis of Factors Causing Waste

Fishbone diagram is used to further analyze three types of waste that occur in the wall paint production line with the highest rating, namely transportation, inventory, and waiting time. Analysis of the factors causing the occurrence of the three types of waste is using a variable on fishbone diagram such as man, machine, material, method and environment.

3.6. Idea for improvement

After identifying and analyzing the causes of the three highest wastage in the wall paint production line, namely transportation, inventory, and waiting, several suggestions for improvement can be given that can be used to minimize the occurrence of this waste. Some of these suggestions can be explained as follows :

Making One Point Lesson; 5S implementation; The 5S concept is a process designed to organize the workplace, keep it clean, and maintain conditions that are effective and in accordance with standards [9], the five steps of implementing 5S consist of Seiri (sort), Seiton (set in order), Seiso (Shine) , Seiketsu (Standardize), Shitsuke (Sustain) [10]; Preparation of Standard Operating Procedures; Joint Cleaning Program ; briefings; Unannounced Examination.

3.7. Future Value Stream Mapping

After submitting several suggestions for improvements that can be made by the company to reduce waste, the flow of information and materials is then described in the future value stream mapping to find out how much improvement can be achieved compared to the initial conditions in the current value stream mapping. Future value stream mapping can be seen in Figure 2.

3.8. Process Activity Mapping after implementing the Idea for improvement.

After describing the manufacturing process into a future value stream mapping based on the proposed assumptions that have been implemented, every activity that occurs on the wall paint production floor is then described in the future process activity mapping. The results of the process activity mapping are then grouped by type of activity and category of activity values which can be seen in Table 5 and Table 6.

From the future value stream mapping depicted in Figure 4 above, it is found that the assumption by implementing the suggestions given can reduce non-value added activity time by 96 minutes, which was originally 200 minutes to 104 minutes. In other words, submitting this improvement proposal can reduce the production lead time by 33 minutes or by 38.82% and increase process cycle efficiency by 16.02% from 47.23% to 63.25%. Comparison results of the actual situation described in the current value stream mapping assuming the proposed improvements have been implemented as described in the future value stream mapping can be seen in Table 7.
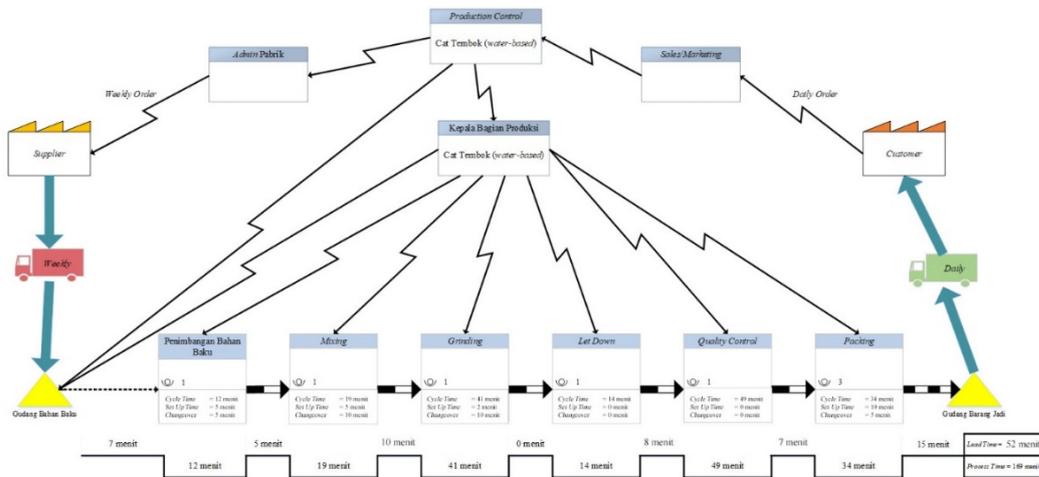
Figure 2. Future Value Stream Mapping

Table 5. Grouping by Type of Activity

Activity	Amount	Time (Minute)	Percent (%)
Operation	11	201	71,03
Transportation	6	54	19,08
Inspection	1	1	0,35
Delay	2	12	4,24
Storage	1	15	5,3
Total	21	283	100

Table 6. Grouping Based on Activity Value

Activity Point	Amount	Time (Minute)	Percent (%)
Value Added	7	179	63,25
Necessary but Non Value Added	12	92	32,51
Non Value Added	2	12	4,24
Total	21	283	100

Table 7. Comparison Between CVSM ans FVSM

Indicator	CVSM	FVSM	Result
Non Value Added Activity	200 Minute	104 Minute	Decrease 96 Minute
Lead Time	85 Minute	52 Minute	Decrease 33 Minute
Process Cycle Efficiency	47,23	63,25	Increase 16,02%

4. Conclusion

The conclusion obtained from this study is that there are three highest wastes that occur in wall paint production activities in companies that are the object of research based on identification analysis using the waste assessment model. The three highest waste sequences were obtained, namely transportation with a value of 20.18%, followed by inventory with a value of 18.30% and waiting with a value of

15.51%. Then, after the flow of information and materials is described in the current value stream mapping, the wall paint production activity which consists of 11 operating activities, 6 transportation activities, 1 inspection activity, 2 waiting activities (delay), and 1 storage activity has process cycle efficiency of 47.23% or value-added activities for 179 minutes; Meanwhile, non-added activities were divided into two, namely necessary but non-value-added activities of 49.60% or 188 minutes and non-value-added activities of 3.17% or 12 minutes.

As a whole, the proposed improvements submitted to this company are assumed to be able to reduce non-value added activity time by 96 minutes, which was originally 200 minutes, to 104 minutes. In other words, submitting this improvement proposal can reduce the production lead time by 33 minutes or by 38.82% and increase process cycle efficiency by 16.02% from 47.23% to 63.25%.

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