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The Integration of Lean Manufacturing and Promodel Simulation in the Shampoo Production Process with the VALSAT and VSM Method Approach

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Abstract**—** *This research was conducted in the manufacturing industry that focuses on producing cosmetic products and household needs, one of which is shampoo. In 2021 the demand for shampoo production will increase. However, the production process time is too long, especially at the foam deposition stage, which lasts 97.4% of the 100% of total shampoo production process time so that it becomes an obstacle for the company because of the waste of activity. For this reason, to minimize waste or activities that do not add value to the company, it is necessary to do. This study uses value stream mapping (VSM) to determine the flow of material and information flow regarding the shampoo production process, followed by finding waste using the waste assessment model (WAM) and value stream mapping analysis tools (VALSAT) Finding Root Cause Analysis (RCA).*

Moreover, the result is that there are 9 critical wastes with a total time of 67766 seconds. Then based on the implementation of the proposed improvement, it was found that the initial production process time decreased from 70720,2. Seconds to 54974.1 seconds or 23%, and simulated using ProModel software with a run time of 15.3 hours, and the result is 5 pcs. By proposing the merging of the production process and the re-layout of the production floor, it will have an impact on reducing the time in the shampoo production process, which will have a positive impact on the company to be more effective and efficient in producing shampoo and products that are accepted by consumers more quickly.

Keywords**—** *Lean Manufacturing, value stream mapping (VSM), waste assessment model (WAM), value stream mapping analysis tools (VALSAT), ProModel.*

I. INTRODUCTION

In today's industrial world, both services and manufacturing industries require a company's commitment to making continuous improvements in all aspects so that companies can remain competitive and continuously improve process effectiveness and efficiency of costs that have been released in the production process so that productivity continues increased and there is no wastage in it. In general, the purpose of the manufacturing industry is to produce goods economically to make a profit and deliver the product on time.

During the current Covid-19 pandemic, the Ministry of Industry is trying to restore the economy and improve the competitiveness of national industries in the Covid-19 pandemic. These efforts are to maintain industrial productivity during the pandemic through the policy of granting Operational Permits and Mobility of Industrial Activities (IOMKI), implementation of making Indonesia 4.0 with seven priority sectors to encourage the growth of the national industry; three main pillars must be a concern, namely investment, technology, and Human Resources (HR). Productivity is an important factor that affects the sustainability and development of the company. Companies must be able to increase output by reducing or saving inputs. The waste influences the output produced by the company in the production process [1-5].

In 2020 the cosmetics sector will grow; this can be seen from the growth performance of the chemical, pharmaceutical, and traditional medicine industries and cosmetics, which grew quite significantly. Cosmetics are expected to continue to be encouraged to use local raw materials.

Because Indonesia has a comparative advantage compared to other countries producing cosmetic products made from natural ingredients, such as China, Malaysia and Thailand. According to data from the Central Statistics Agency (BPS).

PD Budi Andhika is a manufacturing company that produces various cosmetics and household needs. The production process at PD Budi Andhika is carried out starting from processing raw materials to becoming finished products depending on the orders received by the company. The products at PD Budi Andhika include Shampoo, Conditioner, Hair Tonic, Facial Scrub, etc. One of its superior products is Shampoo with various variants, including Apple, Lemon, Green tea, Jasmine, and Fashion Fruit.

Currently, PD Budi Andhika serves several consumers, both from the domestic market in Java and outside Java, as well as the export market from neighbouring countries, namely Malaysia. However, there are obstacles experienced by the cosmetic company PD Budi Andhika in the production process. The problem is the length of time the production process takes to make Shampoo products of various variants. This is due to the very long production process time. So we need an improvement method that can reduce the manufacturing lead time for these products so that the production process becomes more efficient and can be achieved faster.

The following is a table of stage and time data for the production process at PD Budi Andhika:

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TABLE I. Stages and Time of the Shampoo Production Process

No	Production Process Stage	Production Process Time
1	Saponification	1200 sec
2	Foam Precipitation	86400 sec
3	Mixing Flavors	900 sec
4	pH check	30 sec
5	Filling	60 sec
6	Packaging	60 sec

Based on table 1 shows that the shampoo production process from each base (drum) with a size of 150 litres can take a total of up to 88,650 seconds. This is due to the length of the foam deposition stage, which lasts 86,400 seconds, so the foam deposition process has a very long time. Large amounted to 97.4% of 100% of the entire shampoo production process time. This is feared by the company because there is much waste in the production process. On the other hand, with the increasing demand for orders in the period from December 2020 to March 2021, it is feared that there will be a buildup of Work In Progress (WIP) at the foam deposition stage, which will affect the delivery time to customers which will make it take longer for customers to receive the products they ordered.

From the background explanation of the problem above, it is necessary to make an integrated simulation by lean manufacturing regarding the company's ability to carry out the production process to determine the value-added and non-value added at PD Budi Andhika. The company's ineffective and efficient production process causes production to be not smooth, as is the case with the accumulation of raw materials and semi-finished goods (WIP) on the production floor, which is called a bottleneck. [6-14], said that lean is an approach to identifying and eliminating waste or non-value added activities through continuous improvement by flowing products and information using a pull system. System from customers to pursue excellence. Lean manufacturing is a production streamlining concept originating from Japan. This concept is the concept of adoption of the Toyota production system. The concept of this approach is oriented to the elimination of waste that occurs in the production system. This waste elimination is carried out so that the production system runs effectively and efficiently [14-17]. The lean manufacturing concept encourages flexibility in the production system that can adapt quickly to changing customer needs with a lean production system with low inventory. In addition, this approach can reduce unnecessary inventory, increase knowledge about the production process, save costs, reduce defects so that quality increases, reduce production lead times and reduce waste which is expected to improve the production system by eliminating waste and reducing production lead times to reduce delays. Furthermore, it can indirectly reduce production costs, thereby increasing profits. Lean manufacturing is proven to solve problems that are not met, as in the journal of the application of lean manufacturing to increase production capacity by reducing manufacturing lead time [17-20].

The results of the improvements obtained will be simulated using a simulation promodel. The promodel application is an application that is very important and capable of modelling a manufacturing system, service system and business. System testing can reduce the risk of confusing existing structures with unprofitable changes with simulation. Promodel is a software tool that can model various manufacturing and service systems.

The benefit of using promodel simulation is that it avoids the use of expensive costs, does not take a long time and does not interfere with the running system. According to [21-22], before implementing a design and evaluating a system, it can first be simulated to reduce wasted costs and provide an overview of the level of success of a process.

II. RESEARCH METHODS

Stage 1: Value Stream Mapping (VSM)

Creating a Current State Map vsm, namely, identifying the processes that occur from the arrival of materials to finished products, taking pictures of the material process steps, process information flow, and communication relationships that occur in it. Then fill in the operation box (data box) at each processing station.

Stage 2: Waste Assessment Method (WAM)

At this stage, we will identify and measure waste using a questionnaire by the Waste Assessment Model (WAM) method.

Stage 3: Value Stream Analysis Tools (VALSAT)

At this stage, it will identify and measure waste using Value Stream Analysis Tools (VALSAT), which will be used to analyze and further identify by multiplying the results of the weighting of waste with the controlling factors in the Value Stream Analysis Tools (VALSAT) table, then identification will be carried out. The following is the identification of waste using the tools in the Value Stream Analysis Tools (VALSAT):

a. Overproduction

The steps for minimizing this waste are as follows:

1. Calculate the daily production data from December 2020 to March 2021.
2. Create a graph that illustrates the relationship between the total planned production and the actual total production from December 2020 to March 2021.

b. Excessive Inventory

One of the tools that can minimize excessive inventory wastage is to use the Supply Chain Response Matrix with the following steps:

1.Calculating the total lead time data in the shampoo production process.

2.Calculating cumulative inventory on shampoo production.

3.Make a graph that illustrates the relationship between inventory and total lead time to find out and evaluate the level of increase and decrease in inventory and the length of lead time in each area of the Shampoo supply chain.

4.Waiting time, excessive transportation, inappropriate processing, and unnecessary motion One of the tools in VALSAT that can identify these four types of waste is Process Activity Mapping by:

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a. The first step is to directly observe how the existing production process in producing Shampoo and record the activities that occur, the distance travelled, the time required, and the labour involved.
b. The results of these observations need to be grouped into 5 activity groups, namely (1) operations, (2) transportation, (3) inspections, (4) waiting, and (5) storage.
c. 5 activity groups
d. The last step is the analysis of the existing types of activities. Calculating the proportion of non-value-added activities compared to value-added activities is necessary.

Stage 4: Future State Value Stream Mapping (FSVSM)

After making CSVSM, Current conditions describe previous conditions, and of Current conditions, Future conditions must also be made to see the difference between Current conditions, namely Initial conditions and conditions after many improvements have been made.

Stage 5: ProModel Simulation

Create a pro model simulation with an overview of the Future State Value Stream Mapping (FSVSM) process flow.

III. RESULT

Stage 1 Improvement Recommendation

The causes of the waste found from the fishbone result from the problem, so at this stage, the causes are narrowed down the scope of the problem by using the Root Cause Analysis tool to analyze these causes so that the causal factors are found as a reference for making suggestions for improvement. Here is a suggestion using 5W and 1H:

TABLE II. 5W+1H

Factor	WHAT	HOW	WHY	WHEN	WHERE	WHO
	Problem	Countermeasures Plan	Reason	Time	Place	
Machine	Deposition time	Rearrange the production process time	So that no time is wasted		Production Line	PIC
Method	foam too long	Re-lay out the shampoo production process by combining processes	To eliminate unnecessary wastage			PIC
Man	Waiting without doing anything					
Environment	Operators do YOUNG					
Material	Distance between processes	Weighing and material preparation is done early	To speed up the production process		Warehouse	PIC

TABLE III. Process Activity Mapping (PAM) Future Value Stream Mapping (FVSM)

No	Process Name	Activity Details	Tools	Distance (m)	Activity					Time (s)	Accumulation	VA/NVA/NNVA	Total Operator
					O	T	I	S	D				
1	Warehouse	Sending Shampoo Material		4		1				13	13	NNVA	
2	Saponification, Flavor Mixing & pH Checking	Mixing and Stirring Materials With Variants of Flavors and checking pH	MIXER		1		1			1246.4	1259.4	VA	1
3	Foam Precipitation	Precipitating Foam from Shampoo							1	52200	53459.4	NNVA	
		Transferring Shampoo to Filling Process		4		1				16	53475.4	NNVA	
4	Filling	Filling Containers with Shampoo			1					975	54450.4	VA	1
		Close the filled shampoo container			1					17	54467.4	NNVA	
		Transferring the Container That Has Been Filled with Shampoo		16		1				135	54602,4	NNVA	
5	Packing	Packing Shampoo in a box			1					338,7	54941.1	VA	2
		Moving the shampoo that has been packed to the finish good warehouse		8		1				33	54974.1	NNVA	

Re-layout and process integration are the most dominant improvement results because there are non-value-added activities that include the combined process then preparation and preparation of the production process time will greatly assist in the production of shampoo to be more efficient. Simplification and uniformity of the work system for making shampoo products can be done while still paying attention to the achievement of the objectives of each step of the work process carried out. Therefore, data is collected from each process regarding the production line area and the similar

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characteristics of the machines that process shampoo products so that the process can be combined and simplified into one more effective and efficient working procedure.

Stage 2 Process Activity Mapping Recommended

Process Activity Mapping recommendations indicate a change in activity from production after the proposed improvement is given. From the results of calculations using the lean manufacturing method to Reduce Non-Value Added Activity and Necessary but Non-Value Added Activity in shampoo production. The decrease in Non-Value Added Activity and Necessary but Non-Value Added Activity is due to process changes that make shampoo production efficient. Table 3 is Process Activity Mapping (PAM) Future Value Stream Mapping (FVSM).

From Table III, eliminating the critical Necessary but Non-Value Added Activity (NNVA) then combining the Value Added (VA) process for shampoo production efficiency and eliminating the non-Value Added (NVA) process. The following is in table IV, the analysis of the results of PAM before and after repairing the shampoo production process line.

TABLE IV. Recap of Shampoo Activities in Recommended PAM

No	Activity	After (s)	Before (s)
1	Sending Shampoo Material	13	13
2	Weighing Material	122	0
3	Mixing and Stirring Materials	1226.8	1226.8
4	Removing the Mixer Machine	42	0
5	Washing Machine Mixer	63	0
6	Moving WIP Position	16	0
7	Precipitating Foam from WIP	67320	52200
8	Cleaning Remnants of Foam	24	0
9	Transferring WIP to Flavor Mixing Process	113	0
10	Mixing and Stirring Materials with Variants of Flavor	549.06	0
11	Washing Shampoo Stirring Spatula	52	0
12	Moving Shampoo to measure pH	14	0
13	Measuring the pH of Shampoo	19.6	19.6
14	Transferring Shampoo to Filling Process	16	16
15	Filling Containers With Shampoo	32.5	32.5
16	Close the filled shampoo container	17	17
17	Transferring the Container That Has Been Filled with Shampoo	135	135
18	Packing Shampoo in a box	67.74	67.74
19	Moving the shampoo that has been packed to the finish good warehouse	33	33

It can be seen in Table IV above that there is a decrease in the total lead time which shows the lead time of shampoo production. The production lead time from before the repair was 70720,2 seconds to 54974.1 seconds, so the time could be reduced by 15746.1 seconds or 4.4 hours. After repairing the total waste from lead time reduced by 23%, this will make production time run faster so that the company can immediately send its products to consumers, who will impact customer satisfaction and trust in the company.

Stage 3 Future State Value Stream Mapping

Looking at the PAM description in the previous table, the future state value stream mapping can be illustrated as shown below.

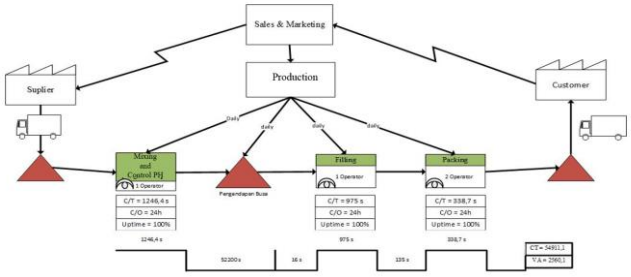

Fig. 1. VSM

Stage 4 Actual Time Promodel Simulation Results

The results of the simulation of the shampoo promodel production process with an actual time of 15.3 hours and a processing time of 54973.9 seconds in producing 150 litres of shampoo products obtained after the model are run are as follows:

Scoreboard

Name	Total Exits	Average Time In System (Hr)	Average Time In Operation (Hr)	Average Cost
Material	0.00	0.00	0.00	0.00
Base Shampoo	0.00	0.00	0.00	0.00
Shampoo	0.00	0.00	0.00	0.00
Finish Good	5.00	15.27	15.21	0.00
Base Shampoo2	0.00	0.00	0.00	0.00
Base Shampoo3	0.00	0.00	0.00	0.00

Fig. 2. Scorecard Shampoo

From the Scoreboard results in Figure 2, it is found that the Total Exits box of Finish goods is worth 5, which means that in the 15.3 working hours of work, 6 boxes of each box contain 6 jerry cans of shampoo or the equivalent of 30 litres. So the product that comes out is 5 boxes of Finish Good multiplied by 30 litres = 150 litres of shampoo. With a production time of 15.3 hours, it is an indicator that the production process is much more efficient and effective than the previous production process, with a production time of 19.7 hours with a time difference of 4.4 hours.

1. Locations

a) Total Entries

Total Entries is the number of entities entered and processed at the destination location. In the simulation model that runs 15.3 hours with a product cycle time of 54973.9 seconds, it is as follows:

Material Warehouse = 150
Saponification = 150
Foam Precipitation = 150
Filling = 30
Packing = 12
Warehouse Rack = 5

b) Avg Time Per Entry (Day)

At this stage, the average production time for each process is as follows:

Material Warehouse = 0.0 Hours
Saponification = 0.64 Hours
Foam Deposition = 14.62 Hours
Filling = 0.19 Hours
Packing = 0.07 Hours

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Warehouse Rack = 0.0
c) % Utilization
In this actual time simulation, the workload at each location is as follows:
Material Warehouse = 0
Saponification = 4.21
Foam Precipitation = 95.46
Filling = 0.26
Packing = 0.4
Warehouse Rack = 0

Stage 5 Model Verification and Validation

Verification and Validation determine whether a model is useful and accurately describes the actual system. So the model simulation for the production process flow of the Lean Manufacturing implementation is carried out to validate that the model made is by the actual results. The model validation is carried out in the following way:
1. Comparing input-output with similar systems that already exist. By entering all input data from the existing system, the resulting output must be identical to the real system running. By entering input from the real system into the model, the output produced by the model is the same as the output produced by the real system, namely, with a production cycle time of 54973.9 seconds and a run time of 15.3 hours, a total entity exit of 5 boxes is obtained. This indicates that this model has passed the validation test with good results.

TABLE V. Model Verification and Validation

No	Verification	Hasil
1	Has the number of carriers aspects been loaded according to FVSM?	YA
2	Is the locations aspect loaded according to FVSM?	YA
3	Has runtime been loaded according to FVSM?	YA
4	Has the routing for material been loaded according to FVSM?	YA
5	Does the simulation interface run according to the process flow?	YA
6	Is there no language/sentence error in the operation tab of the logic process on the debug menu using the compile function in the Promodel software?	YA (Compiled Successfully)

Model validation using the average comparison formula in the following equation

$$E = \frac{\overline{F} - \overline{P}}{\overline{P}}$$

Where : $\overline{F}$: Average output value based on FVSM

$\overline{P}$: The average value of the output on the total exit of the promodel simulation

- If E = ….. < 5% (0,05) then Validation is accepted
- If E = …...> 5% (0,05) then Validation is rejected
- $E = \frac{54974,1 - 54972}{54972}$ =0,00004

Validation accepted because E = 0,00004 < 5% (0,05)

Based on the results of the calculation of the average comparison formula on the validation of the promodel is accepted because the validation value is 0.000004 < 5% (0.05)

IV. CONCLUSION

Conclusion

The conclusions that can be drawn from this final project are as follows:
1. Based on the results of knowing the waste in the production process by knowing the material flow and information on the shampoo production process using current state value stream mapping, then identifying waste using the Waste Assessment Questionnaire (WAQ), Value Stream Analysis Tools (VALSAT) method and looking for waste critical waste using the Root Cause Analysis (RCA) method using fishbone diagram tools and continued with 5 Whys and obtained critical waste, namely operational waste totalling 4 activities and 251 seconds NNVA, transportation waste totalling 2 activities and 129 seconds NNVA time, and waiting for a waste of 67320 seconds NNVA and 2 non-value-added (NVA) activities respectively on transportation and operation, namely the process of washing the shampoo stirring spatula and moving the shampoo to measure pH takes a total of 66 seconds.
2. By knowing that there are 9 critical wastes with a total time of 67766 seconds of critical waste, it is proposed to make improvements by rearranging the production process time and re-layout the shampoo production process by combining the processes in the flavour mixing process. as well as checking the pH into the saponification process so that a decrease in the total production time will be obtained shampoo as a whole with a time before repair of 70720,2. Seconds to 54974.1 seconds so that the time can be reduced by 15746.1 seconds or 4.4 hours; this will make the shampoo production process time run faster because the total waste improvement from the shampoo production process is reduced by 23%.
3. Simulating the improvement results from Future Value Stream Mapping (FVSM) using the ProModel simulation with the total shampoo production time at FVSM, which is 54974.1 seconds and a run-time setting of 15.3 hours, using 6 locations, namely, material warehouse, saponification, foam deposition, filling, packing, and warehouse racking with the simulation results of the total exit (goods coming out) of 5 boxes of Finish Good.

Suggestion

The following are suggestions that can be given based on the results of the final project research that has been carried out.
1. Continuous improvement must always be carried out on the company's production line, not only in the shampoo production process but also in the production process of other products, so that the company's production line runs more effectively.
2. The need for the use of appropriate machines to support the performance of the shampoo production line to be more effective and efficient.

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