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Analysis and Minimization of Waste in the Production Area of PT. XYZ with Lean Manufacturing Approach and System Simulation

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Abstract. *PT. XYZ is a manufacturing company engaged in the manufacture of packaging cardboard. In the production process at PT. XYZ still found the presence of waste, especially in defects, waiting, and excessive transportation. This study aims to minimize or eliminate waste by providing recommendations for improvement using a lean manufacturing approach, then the improvement recommendations are designed through system simulation using proModel software. The lean manufacturing method used in this research is Value Stream Mapping (VSM) to map the entire value stream in the production process from start to finish, where the VSM manufacturing process is supported based on the tools selected from the Value Stream Analysis Tools (VALSAT). Furthermore, to find the root cause of waste, Fishbone Diagram is used, and to determine the cause of the most critical waste, the Failure Mode and Effect Analysis (FMEA) method is used. The results showed that with the improvement recommendations given, the processing time could be reduced from 9743.70 seconds to 6417.15 seconds, and based on the simulation results the improvement showed an increase in the average number of products per month which was 64.26% with an increase from 52962 pcs to 87000 pcs.*

Keywords: *waste, lean manufacturing, value stream mapping, fishbone diagram, failure mode and effecr analysis*

I. INTRODUCTION

The development of technology and industry that is increasingly advanced in the current era of globalization makes competition among companies also increase so that this makes the company must be able to maintain the business it manages, to maintain and continuously increase the company's profit, a careful calculation and planning are needed (Antandito et al., 2017). Discussing manufacturing companies, one of the important things to make improvements is to improve the production process first by minimizing or eliminating all production activities that do not provide added value or are commonly known as waste. Seven types of waste are often experienced by companies in the production process, namely transportation, inventory, motion, waiting, overprocessing, overproduction, and defects (Anthony, 2018).

PT. XYZ is a company engaged in the manufacture of packaging cardboard which was founded in March 2018. Based on the results of field studies and interviews, it is known that PT. XYZ also does not escape the existence of waste in its production activities. The type of waste that often occurs in PT. XYZ is a waste of defects and a waste of waiting. Waste that occurs at PT. XYZ causes the company to waste a lot of production time, so it becomes less effective in carrying out its production process. A lot of wasted production time causes companies to often experience delays in product delivery to customers from a predetermined due date, so companies must reschedule shipments by asking for additional time from customers. Table 1 shows data on delays in the delivery of finished products to customers of PT. XYZ.

Table 1. Delay Data Percentage

Delivery Type	Delivery Quantity (times)	Percent -age
Amount of Late Delivery	113	67.26%
On-time Delivery Quantity	20	11.90%
Faster Delivery Quantity	35	20.84%
Amount	168	100%

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Based on the table above, it was found that 113 deliveries that were delayed from a total of 168 shipments with a percentage reaching 67.26% made during the January-December 2021 period. Some of the causes of waste defects are raw materials that are not good, machine setting errors, operator negligence in the printing and coloring process, the cutting process, and the gluing process. Meanwhile, the cause of waste waiting is the machine is busy, so other products must wait to be processed. Waste waiting also occurs because the machine settings are quite long. The waste that occurs at PT XYZ if left unchecked will reduce the time effectiveness of the production process thereby reducing the company's productivity. Therefore, it is necessary to improve the production process of packaging cardboard at PT. XYZ by applying the concept of lean manufacturing so that the production process time can be minimized so that the productivity and profitability of the company can increase. Lean manufacturing is a continuous effort to minimize waste and increase value added to products (goods/services) to provide value to customers (Armyanto et al., 2020).

The lean manufacturing tools used in this research are VSM (Value Stream Mapping). VSM is a description of the entire production process from raw materials to products received by consumers, equipped with information at each production station such as cycle time, and the number of operators (Febianti et al., 2018). Furthermore, the Fishbone Diagram is used to identify the causes of waste at PT. XYZ. A Fishbone diagram is a method to improve quality where this diagram will show the impact of a problem with various causes (Gaspersz, V., & Avanti, F., 2011). Then to determine the cause of critical waste, the FMEA (Failure Mode and Effect Analysis) method is used, which is a structured and systematic method that can identify and analyze the consequences of process and system failures, to minimize the chances of failure (Render, B., & Heizer, J., 2015). Based on the explanation above, it is known that the purpose of this study is to determine the largest type of waste that occurs in the production area of PT. XYZ, identify and analyze the factors that lead to waste in the production area of PT. XYZ and knowing the impact of this waste, and providing suggestions for improvement in the form of a more effective and efficient production system design through a lean manufacturing approach and making a simulation of the proposed improvement using proModel software.

II. Research Method

Sources of data obtained directly from the company in the form of quantitative data and qualitative data. Quantitative data obtained from company documents and archives includes product flow process data, cycle time data, distance data between processes, data on types of defects that occur in the company, as well as distributing 7 waste questionnaires and filling out FMEA worksheets. Qualitative data obtained from direct observations in the company and data from interviews with workers at PT. XYZ.

The method of collecting is by means of observation, interviews, questionnaires and documentation. The data collected includes company profile data, output data on the number of products, data on the number of defective products, data on product delivery delays, and so on which are used to support this research.

Data that has been obtained is then processed with a sequence of data processing steps, namely calculating the results of the score and ranking of the 7 waste questionnaires, calculating VALSAT, making Current Value Stream Mapping, identifying and analyzing waste using Fishbone Diagrams and Failure Mode Effect Analysis, making Future Value Stream Mapping, making simulation models of actual conditions using proModel software, verifying, testing replication, and validating actual simulations, as well as making proposed simulation models.

III. Result and Discussion

Seven Waste Questionnaire Ranking and VALSAT Calculation

After distributing the seven-waste questionnaire, the results were obtained for the 3 wastes with the highest ranking, namely defect waste with an average score of 3.82, waiting

Table 2. Percentage of Activity Amount and Time

Activity	Value	Total Activity	Percentage	Time (Second)	Percentage
Operation	NVA	17	41.46%	4482.02	46.00%
Transportation	NNVA	8	19.51%	2755.60	28.28%
Inspection	-	6	14.63%	-	-
Storage	-	2	4.88%	-	-
Delay	NVA	8	19.51%	2506.08	25.72%
Amount	**0.084**	**41**	**100%**	**9743.70**	**100%**

waste with an average score of 2.27, and waste excessive transportation with an average score of 2.20. The three wastes with the highest rank are for further analysis. Based on VALSAT, the tool with the highest score is Process Activity Mapping (PAM) with a score of 59.71.

Actual Process Activity Mapping (PAM)

After making the PAM, the percentage results of the recapitulation of the number and time of activities are shown in Table 2.

In table 2 it is known that there are 41 activities to produce packaged cardboard products at PT. XYZ with a total production time to make 100 pcs of cardboard packaging is 9743.70 seconds.

Current Value Stream Mapping (CVSM)

Based on CVSM, it is known that the production process of making cardboard packaging at PT. XYZ has 4 production processes, namely the design printing process, the cutting process, the gluing process, and the packing process. The total time of Value-Added Activity (VA) is 4482.02 seconds, the total time of Necessary but Non Value Added Activity (NNVA) and Value Added Activity (NVA) is 5261.68 second.

Identify Waste Using Fishbone Diagram and FMEA

The defect product is the biggest waste experienced by PT. XYZ. The largest number of product defects occurred in the production line of Longway machines - Slotter machines - Finishing Glue machines, so this research focuses only on these production lines. Based on the p-Chart, the proportion of the number of defective products that occur in the production area of PT. Many XYZ still exceed the control limits, which means that the resulting defective products are out of control and become a serious problem.

Based on the identification of fishbone diagrams and FMEA, the most critical causes of waste defects are poor quality raw materials, machine conditions that experience problems when used, and machine setting errors.

Waste waiting in the process of making cardboard packaging at PT. XYZ occurs in 2 conditions, namely process waiting and machine waiting. In waste waiting, the most critical cause of waste is Slotter machine workstations and Finishing Glue machines which experience high activity so that the product cannot be processed directly on the machine because the machine is still working on other products. Waste waiting is also caused by the lack of operators in moving goods, so the machine has to wait before the product is brought to the workstation.

Lastly, for waste excessive transportation, the most critical cause is semi-finished products that must be carried back and forth due to busy Slotter machine workstations and Finishing Glue

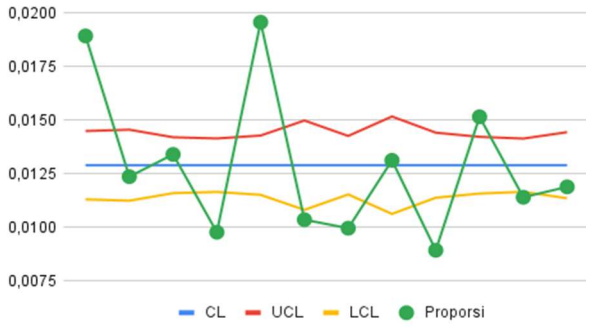

Figure.1. P-Chart Defect Product

machines, so the product cannot be directly processed in the machine and must be stored in the storage area first.

Process Activity Mapping (PAM)

The suggestion given to minimize defect waste is to add 1 Quality Control staff because currently there is only 1 QC staff who handles the entire inspection process, thereby increasing the chances of passing inspections of raw materials that are not up to standard. In addition, another suggestion given is to choose a supplier that provides the best service so that the quality of raw materials can be maintained. Then, a maintenance schedule can be carried out because there is no structured machine maintenance schedule at PT. XYZ. The last suggestion given is to provide a training schedule for old operators or daily workers to increase the operator's ability to minimize the occurrence of machine setting errors that can result in defective products.

Waste waiting, namely busy machines during the production process, is a critical cause of waiting for processes at workstations for Slotter machines and Finishing Glue machines, this waste can be minimized by increasing machine working hours at each workstation to reduce machine busyness due to high demand. The proposal to increase working hours is to create a shift system as follows:

Shift 1:

- Working days : Monday – Friday
- Working Hours : 08.00 – 16.00
- Break Time : 12.00 – 13.00

Shift 2:

- Working days : Monday – Friday
- Working hours : 17.00 – 22.00
- Break time : 18.00 – 19.00

In addition, the lack of operators to move products from one place to another is the cause of waiting machines at workstations for Longway machines, Slotter machines, or Finishing Glue machines, this waste can be minimized by adding 1 operator on special duty to move goods to reduce waiting time machine.

Semi-finished products carried back and forth due to busy machines are the cause of excessive transportation waste at Slotter machine workstations and Finishing Glue machines, this waste can also be minimized by increasing machine working hours at each workstation to reduce machine activity so that the finished product is have been completed from one workstation can be directly brought to the next workstation.

Simulation Model Design Using Software Pro Model

Before making a simulation based on the proposed improvement, first an actual simulation model is made to prove that the simulation made can represent or describe the actual conditions in the company. Furthermore, a proposed simulation model can be made, and the proposed simulation results are obtained as shown in Figure 2 ans Table 3.

Based on the table above, it is known that after repairs can increase the average production

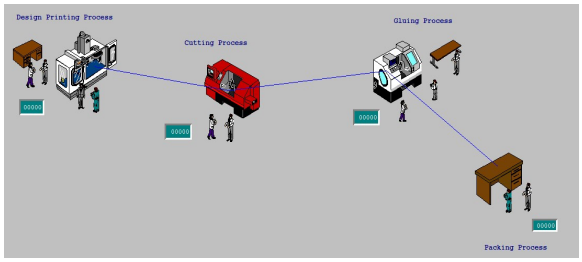

Figure 2. Proposed Simulation of PT. XYZ

Table 3. Recapitulation of Proposed Data Simulation Results

Period	Total Actual Production (units)	Proposed Simulation Results (units)	Difference (units)
1	45092	87000	41908
2	41767	87000	45233
3	67357	87000	19643
4	73652	87000	13348
5	59878	87000	27122
6	26388	87000	60612
7	61510	87000	25490
8	22190	87000	64810
9	49776	87000	37224
10	65432	87000	21568
11	74258	87000	12742
12	48244	87000	38756
Average	**52962**	**87000**	**34038**

output from 52962 to 87000 pcs of packaging boxes with a percentage increase of 64.26%.

IV. CONCLUSION

Based on the results of data processing, it was concluded that there were 3 types of the largest waste experienced by PT. XYZ is waste defect with an average score of 3.82, then waste waiting with an average score of 2.27 and waste excessive transportation with an average score of 2.20. Then identify the causes of waste using a fishbone diagram and to find the cause of the most impactful or most critical waste, the FMEA method is used, so that it can make it easier to propose improvements. Based on the proposed improvement, the time of the production process for making cardboard packaging at PT. XYZ can be reduced from 9743.70 seconds to 6417.15 seconds and shows an increase in the average number of productions per month which is 64.26% with an increase from 52962 pcs to 87000 pcs.

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