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LEAN MANUFACTURING APPROACH USING COST INTEGRATED VALUE STREAM MAPPING TO REDUCE WASTE IN FAKE EYELASHES PRODUCTION FLOOR

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ABTSRACT

Fake eyelashes are made in Indonesia by a variety of industries. There are issues within the company that have an impact on the output. Waste issues in the manufacture of fake eyelashes are the cause of inconsistent production output, such as flaws in the goods, waiting times, and improper processing. A lean manufacturing approach is required to find a solution to the issues that PT. X is experiencing as a result of the data model. The Value Stream Mapping (VSM) method, the Activity Based Costing (ABC) method integration, the Value Stream Analysis Tools (VALSAT) method calculation, the Root Cause Analysis (RCA) method, and then gives recommendations for improvement. The use of continuous flow, task combinations, and the delivery of raw materials once each week are all suggested improvements. When current cost integrated value stream mapping is compared to future cost integrated value stream mapping, the production lead time drops from 0.5 days to 0.36 days, the total value-added cost drops from 2.049 to 1.561, the total non-value-added cost drops from 12.754 to 11.243, and the travel distance drops from 99 meters to 79 meters.

Keywords: Waste, Lean Manufacturing, Value Stream Mapping, Activity Based Costing

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1. INTRODUCTION

Every industry, whether it be in manufacturing or services, aspires to raise the standard and productivity of its operations in a number of ways. The ability of a corporation to carry out its production activities as effectively as feasible can be seen from the productivity of that company. The end product will be of excellent quality and less waste will be produced with an effective and productive production system (Antandito, D. J., 2014). The manufacturing company PT. X creates fake eyelashes. A make-to-order production system is used by PT. X to carry out production in accordance with customer requests. Based on the findings of the document studies and interview data, the total production of PT. X from January to March 2021 averaged 431,431 units. There will be a 5983-piece gap between demand and production capacity in February 2021 when product demand exceeds production capacity and capacity only hits 444,570 units. Waste issues in the manufacture of fake eyelashes are the cause of inconsistent production output. A lean manufacturing approach is required to find a solution to the issues PT.X is experiencing in order to decrease waste on the production floor. By incorporating the Value Stream Mapping (VSM) flow and the Activity Based Costing (ABC) approach and then distributing the seven-waste questionnaire with board weighting calculations to determine the largest waste (Pandya, H. B., Shah, S. I. 2017). VSM not only can used in production floor manufacturing area, but can use in construction bussines (Morato et al 2024)

The next step is to determine the biggest waste using the Value Stream Analysis Tools (VALSAT) technique, and then utilize Root Cause Analysis (RCA) to identify the main reason why issues arise and offer suggestions for improvement.

Continuous improvement is a component of the lean manufacturing approach, which aims to increase value added and decrease product waste in order to satisfy customers (Ari Zaqi Faritsy, S.,2015). Value Stream Mapping (VSM) is produced using this lean manufacturing methodology in order to comprehend the information flow from each production process activity in the organization (Sri Indrawati et al, 2018). The Activity Based Costing (ABC) approach is then integrated into Value Stream Mapping (VSM), a process known as Cost Integrated Value Stream Mapping (Abuthakeer, S. S., 2010), to compute a cost analysis to aid in decision-making. Each production activity that results in a different cost component is identified by Activity Based Costing (ABC) (Summer, C.R., 1998). The idea behind the Activity Based Costing (ABC) system is that expenses are incurred by activities that employ resources, such as labor, raw materials, machinery, and so forth (Rahman, I., 2013). The Value Steam Analysis Tools (VALSAT) method uses a future state map that is included in the VALSAT matrix to determine the largest waste (Rich, P. H., 1997). The idea behind VALSAT is to contrast the seven wastes using the VALSAT mapping tools that are provided in the matrix (Rich, P. H., 1997). There are seven different categories of waste, including flaw, waiting, excess production, motion, excess processing, transportation, and inventory (Hines, P., 2018). To identify waste that occurs on the manufacturing floor, current research also employs the Value Stream Analysis Tools approach and cost integrated value stream. It is crucial to consider cost integration in order to optimize the production process. Waste can have an impact on a production system's efficacy and efficiency as well as production costs during the continuous production process (moses et al. 2024).

In businesses with capital-intensive models, where automation and continuous production processes are in use, the lean manufacturing technique is extensively adopted. Value Stream Mapping can effectively minimize a significant amount of waste in manufacturing and assembly in the automobile sector (Pandya, H. B., Shah, S. I. 2017). The results of implementing lean manufacturing with VSM in the batik industry with a home-based production scale can minimize waste and simplify production in addition to industries with continuous production lean models that can also be applied in small and medium businesses (Sri Indrawati et al,2018). In order to solve the challenge of lean manufacturing in the artificial eyelash sector, which requires a labor-intensive production model, numerous studies on the lean manufacturing strategy with value stream mapping have been conducted. Using the cost integrated values stream mapping method, Value Stream Mapping (VSM) and Activity Based

Costing (ABC) are combined in order to better understand how much of an impact change in lean manufacturing have on costs.

2. RESEARCH METHODOLOGY

Lean Manufacturing and Value Stream Mapping

Many businesses are looking for methods to increase productivity and performance with the goal of remaining competitive. Many businesses are seeking out techniques to enhance the performance of their products. Many businesses that put a strong emphasis on tools for improving quality, productivity, and manufacturing costs have achieved success in the field of process optimization. In general, limitations in the description of production systems, production simulation systems to assess what needs to be done, or sophisticated scenarios do not address many issues or offer answers.

Discrete event simulation and Value Stream Mapping (VSM) can be utilized as decision-making tools to direct management in scenarios and investments based on the best possibilities produced by the VSM (Helleno, A.L. et al,2015). By identifying waiting periods and items that don't contribute value, value stream mapping is a tool used to describe the benefits of production streamlining (Sudhakar, N. et al, 2017). Value stream mapping is an effective method for production streamlining that helps define and pinpoint the waste-reduction process (Taylan, T. et al 2022).

Making continual improvements throughout the process line can be seen as lean (continuous improvement). In every production process, minimizing non-value-added activities (NVA) is the major goal (Gaspersz,2007). Toyota introduced just-in-time manufacturing, later referred to as lean manufacturing. Lean manufacturing aims to increase the productivity of the manufacturing sector. Application of lean manufacturing principles to shorten production lead times and boost output through waste reduction (Ristyowati, T., 2017). The Value Stream Analysis Tools (VALSAT) matrix is a method for identifying the biggest waste by constructing a future state map (Rich, P. H., 2000).

Time Study

1. Tack Time

Takt time is the time required to fulfill production demand (Fadhilah Al K,2017), the formulation is:

$$\text{Production Takt Time} = \left(\frac{\text{Total Working Hour / Day}}{\text{Total Demand / Day}}\right)$$

2. Cycle Time

Cycle time describes the time required to complete one unit of the production process at each workstation (Pandya, H. B., 2017).

$$\text{Cycle Time} = \frac{\sum \text{Observation}}{\text{Total Observation}}$$

3. Normal Time

Normal time is working time whose adjustment factor has been considered. The rating factor helps normalize workers' working time due to different speeds. Based on Westinghouse in determining the rating factor, there are four assessments: skills, effort, consistency, and working conditions (Lusia et al, 2016).

$$\text{Normal Time (NT)} = \text{Cycle Time x } \left(\frac{\text{rating factor}}{100\%}\right)$$

4. Standard Time

Standard time is the actual time in producing one unit of product. Standard time has considered the allowances given to workers to rest to eliminate fatigue or other unavoidable obstacles (Lusia et al, 2016).

$$\text{Standard Time} = \text{Normal Time x } \left(\frac{100\%}{100\% - \text{allowance}}\right)$$

Cost Integrated Value Stream Mapping

Costs are incorporated into the value stream as part of a technique called a cost integrated value stream, and the resulting combination can aid in decision-making and help to concentrate on areas that could use improvement Antandito, D. J., 2014). In this cost-integrated value stream, there are two categories of costs that are calculated: expenses that add value and costs that don't (cost non-value added) (cost value added). These costs include direct costs for each production activity as well as holding costs for each inventory.

Process Analysis

Activities in process analysis are designing a timeline. The timeline has two activities. Namely, value added (VA) and non-value added (NVA) activities (Abuthakeer, S. S., 2010).

$$VT = CTI$$

$$NVTi = \frac{Ii}{Di}$$

$$\text{Processing Time} = \sum_{i}^{n} CTi$$

$$\text{Processing Lead Time} = \sum_{i=1}^{n+1} \frac{Ii}{Di}$$

Description:
VT = Value Added Time (minute)
NVTi = Non value added (minute)
CT = Cycle Time (minute)
I = Inventory (unit)
D = Demand per day (unit)
i = Conclusion index (1,2,3,..,n)
n = Upper Limit Summation

Cost Analysis

The activity of cost analysis is to integrate costs in the value stream and the existing timeline in Value Stream Mapping (VSM) (Abuthakeer, S. S., 2010). These costs include direct costs in each production activity and holding costs per inventory.

$$\text{value added activity cost} = mi + CTi\left(\frac{Mi + Li}{3600}\right)$$

$$\text{non value added activity cost} = hi \text{ x } Ii$$

$$\text{Total value added cost} = \sum_{i=1}^{n} mi + CTi\left(\frac{Mi + Li}{3600}\right)$$

$$\text{Total non value added Cost} = \sum_{i=1}^{n+1} hi \text{ x } Ii$$

Description:
CT = Cycle Time (minute)
M = Machine Rate per Hour
L = Operator Rate per Hour
m = Material Costs
I = Inventory (unit)
h = Holding cost inventory
i = indeks Summation (1,2,3,..,n)
n = Upper Limit Summation

This research uses Cost Integrated Value Stream Mapping method. The following is a description of the methodology of this research. Early stages of research. The initial stages of the study were to make direct observations and see the problems found in PT. X and will be answered in this study.

Identification of problems

Establish the problem's formulation, including the different types of waste, the contributing variables, cost calculation methods, and suggested improvements using a lean manufacturing methodology. The next step is to decide on the research's goals in order to determine how it will proceed after the problem has been formulated. By doing this, we can offer the ideal solution to the issue. Literature study was conducted to obtain related references obtained from theses and previous theses, books, journals and other related written objects. In order to assist in determining solutions to existing problems at PT. X.

3. RESULTS AND DISCUSSION

Data Collection

Production demand data in table 2 is presented at PT. X in March 2021. From the data described that the largest production demand is for Kiss products with the highest number among Kara and Oem products so that it becomes the object of observation of this research. The following is the production data of PT. X in March 2021:

Table 1. Fake Eyelash Production Data

No.	Product	Demand (March 2021)
1	Kiss	330929 pcs
2	Kara	327200 pcs
3	Oem	130100 pcs

Data Processing

This stage is the stage of the data that has been determined to be processed and analysed. The results of data processing consist of making a current integrated value steam mapping with product request documentation, calculating takt time, total value stream inventory, calculating WIP, total product cycle time, lead time, calculating costs in the value stream (total value added cost and non-value added cost). value added cost, identify the waste that occurs in VSM with a seven waste questionnaire and calculated using the Board method to get the largest waste result then, the results are compared with the value stream analysis tools matrix to determine the mapping tools. Finally, make a future cost integrated value steam map design from the results of the Value Stream Analysis Tools matrix.

1. Time Study Processing

Real time monitoing in production floor is be dificult, can use Cycle time monitoring. (Chuang, X., Li, L., Zhu, L. et al 2025). Cycle time is one of the data needed to create a current cost integrated value stream mapping. Cycle time calculation is used to determine the value-added time in the fake eyelash production process (kiss). Calculation of cycle time is carried out in each process repeatedly by observing 30 times using a stopwatch, such as table 2.

Table 2. Time Study Data Processing for Each Workstation

Workstation	WS 1	WS 2	WS 3	WS 4	WS 5	WS 6	WS 7	WS 8	WS 9	WS 10	WS 11
Total *time study*	437,70	21,18	198,40	53,46	24,98	39,29	125,8	302	52,56	186,30	186
Rating	1,05	1,06	1,03	1,08	1,03	1	1,08	1,03	1,03	1,11	1,08
Number of observations	30	30	30	30	30	30	30	30	30	30	30
Cycle Time	13,05	0,71	6,61	1,78	0,83	1,31	4,19	10,09	1,75	6,21	6,21
Normal Time	13,07	0,75	6,81	1,92	0,86	1,31	4,53	10,4	1,80	6,89	6,71
% *Allowance*	15%	15%	15%	15%	18%	15%	15%	15%	15%	15%	15%
Standard Time	15,76	0,86	7,83	2,21	1,03	1,51	5,21	11,9	2,08	7,93	7,71

One of the challenges in time study processing is the operator. Cycle time means showing the running time of the birth process per product. Operators can calculate their time study if they are in normal conditions. The method of determining the time study means the time required to carry out the operation under the conditions that meet the requirements. The operator is in a trained condition, working at a standard speed, exerting an effort to function normally. Certain basic requirements before undertaking a time study should be carried out. If a method or part has been changed, the operator must be thoroughly acquainted with the new technique before the operation is learned (Lusia et al, 2016).

2. Current Value Stream Mapping

From the data on the demand for fake eyelashes production in March 2021, the kiss product was selected as the object of research. After knowing the selected product, the next step is to describe the mapping of the production process for fake eyelash products in their current condition. The following is picture 1 which is the current integrated value stream mapping of 11 workstations.

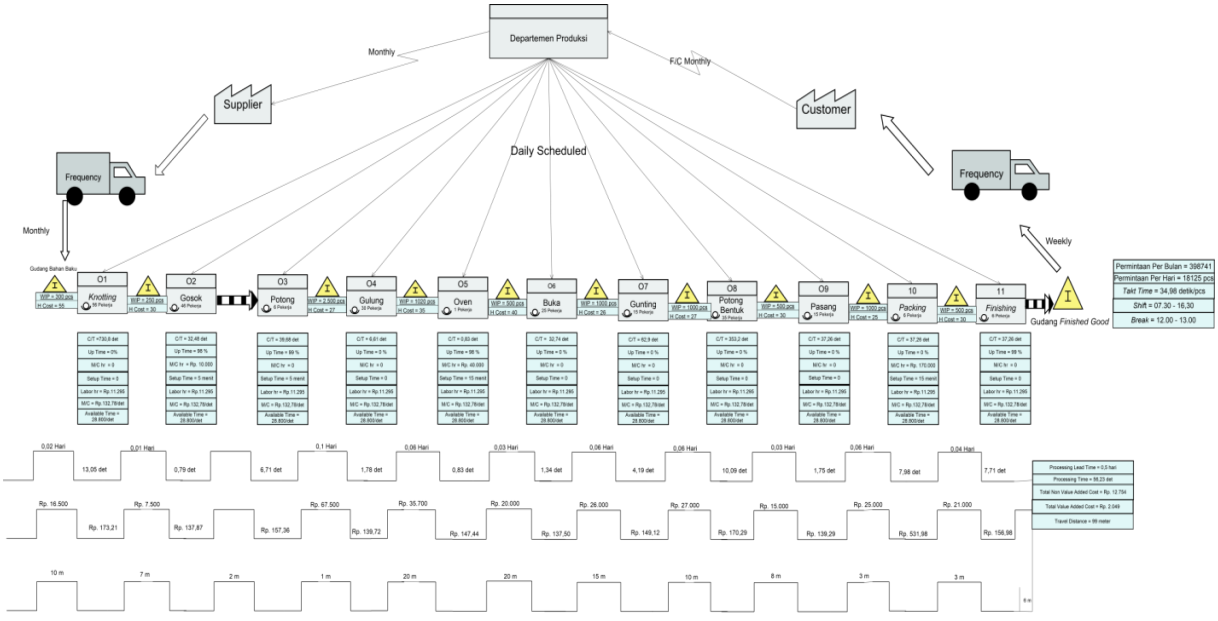

Figure 1. Current Cost Integrated Value Stream Mapping

Figure 1's mapping visualization provides a thorough depiction of the present production process. Figure 1 depicts a current image of the Cost Integrated Value Stream Mapping at PT X. Value Stream Mapping demonstrates decisions made at the production level based on takt time, production schedules, operational bottlenecks, continuous flow, combining production systems, and process enhancements along the chain. through cycle-time development (Farook A. S, et al 2021). As a generic benchmark, value stream mapping takt time can be employed. It can be said that a process is not in a lean condition if the sum of the cycle times for all active processes exceeds the takt time. The takt time value is 34.98 seconds in the Current Cost Integrated Value Stream Mapping Figure 1, while the cycle time is 52.74 seconds. Figure 1's process demonstrates that there is some wastage occurring between the active operations and therefore PT X's manufacturing process is not lean. One of the choices for further lean manufacturing improvement is the response to takt time on the present value stream mapping (Farook A. S, et al, 2021).. There has been a development in the method that allows the costs incurred throughout the value stream mapping process to be incorporated to the cost-integrated value stream mapping, whereas value stream mapping generally does not show the costs incurred. The overall non-value added cost was IDR 12,754 and the total value added cost was IDR 2,094, according to Figure 1. Information on these expenses is crucial because, depending on how much waste we can cut, either the total non-value-added costs will go down or up.

3. Seven Waste Analysis

The frequency of waste that took place on the factory floor was discovered using the Borda method's calculation of the questionnaire's responses. To determine the relationship between the seven wastes and the most recent application of the waste assessment questionnaire to determine the final weight of the seven waste ratings, seven wastes can display a relationship matrix (Henny, 2018). Table 3 displays the outcomes of the seven wastes' scores

Table 3. Results of Seven Waste Weights Score

Waste Type	Weight Score
Overproduction	14%
Defect	23%
Waiting	16%
Transportation	9%
Inventory	9%
Motion	14%
Innapropriate Processing	16%

The most dominant type of waste based on table 3 is the type of defect product with a percentage of 23%, waiting process with a percentage of 16% and inappropriate processing with a percentage of 16%.

4. Process Activity Mapping Analysis

The activity mapping process is used to map activities and to eliminate waste, inconsistencies in the production area so that performance can be streamlined by improving quality, speeding up processes and reducing costs. In the activity mapping process, there are several activities, namely, non-value added (NVA) activities, value added (VA) activities and necessary but non-value added (NNVA) activities. Operations and inspection activities represent value-added activities (VA), delay represents non-value-added activities (NVA) and transportation, storage is non-value-added but necessary activities (NNVA).

Table 4. Score Amount and Proportion of Time for Each Production Activity

Activity	Count	Time (Second)	Percentage	VA	NNVA	NVA
Operation	10	3638,33	1%	39,11		
Transportation	7	3610,46	1%		3617,2	
Inspection	1	16	0%	16		
Storage	2	56,5	0%		56,5	
Delay	2	144000	98%			147600
Total	20	147683,7	100%	55,11	3673,7	147600

The results of value-added activities (VA) are 11 activities including operating and inspection activities with a total time of 55.11 seconds with a percentage of operations of 1% and inspections of 0%. The total activities of non-value added (NVA) activities are 2 activities including delay activities with a total time of 147,600 seconds and a delay percentage of 98%, then for non-value added but necessary activities (NNVA) as many as 9 activities including transportation activities, storage with the total time is 3673.7 seconds and the percentage for transportation is 1% and for storage is 0%.

Finding the root of an issue is done through a method called root cause analysis (RCA). It is an essential step in manufacturing since the production process can be improved only after identifying the root cause and treating it (E Oliveira, E. et al, 2022). The causes of the root causes of waste from the three most dominant wastes are, operators who are less careful, machines and tools that require preventive maintenance, materials that break and break easily, inspections that are less than optimal and high production schedules.

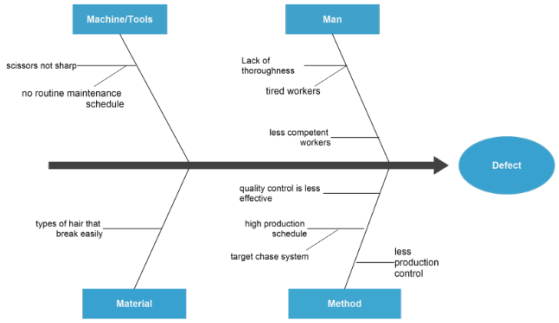

Figure 2. RCA Waste Defect

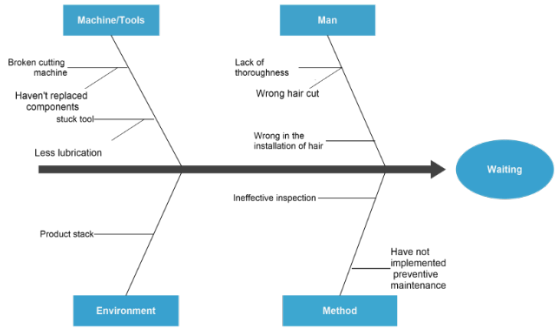

Figure 3. RCA Waste WaitingFigure 4. RCA Waste Inappropriate Processing

5. Future Cost Integrated Manufacturung

a. Continuous Flow

Application of lean concept to fake eyelash production process with one continuous flow. So that in making future integrated value stream mapping, it is applied to the knotting process to the rubbing process and the scissors process to the shape cutting process. Continuous Flow Production is a production method where products move continuously through a series of processes without interruption or delay (Kang et al 2025). The application of continuous flow in these four processes by adding a trolley as a means of transportation. The distance from the knotting process to the rubbing process is reduced by 7 m, for the inventory cost of IDR 7,500. For the process of scissors to cut shapes reduce by 20 m. Then for inventory costs reduced by IDR 27,000.

b. Job Combination

Combination of work in the packing process and the finishing process. Merging work is done to streamline the packing and finishing process so that the place is not separated from the next process. The reason for the merging of work is to facilitate quality control before the product enters the finished good warehouse. For the packing and finishing process, the distance is reduced from 6 m to 3 m, and finally the inventory cost is reduced to IDR 21,000.

Job combination and to prioritize jobs, job scheduling rules like Slack/Remaining Operations and Critical Ratio have been used. (Raju et al 2024)

c. Delivery of Raw Materials

Changing the schedule of raw materials from monthly to weekly so that there is no accumulation of raw materials in the warehouse. So that the delivery from the supplier is 322 kg to 80.5 kg.

Table 5. Changes in Cost Integrated Value Stream Mapping

No	Activity Changed	Reason Changed	Result
1.	Delivery of raw materials by suppliers becomes weekly	To minimize inventory levels in the warehouse	Reducing from 322 kg to 80,5 kg
2.	Continuous Flow Applied	Reducing work in process, transportation, and distance	The distance from the knotting process to the rubbing process is reduced by 7 m for the inventory cost of IDR 7,500. For the process of scissors to cut shapes, lower by 20 m. Then the inventory cost is reduced by IDR 27,000.
3.	Combination of work in the rolling process and the opening process, then the packing and finishing process	Reduce inventory cost, Reducing work in process, transportation dan distance.	For the packing and finishing process the distance is reduced from 6 m to 3 m, and finally the inventory cost is reduced to IDR 21,000

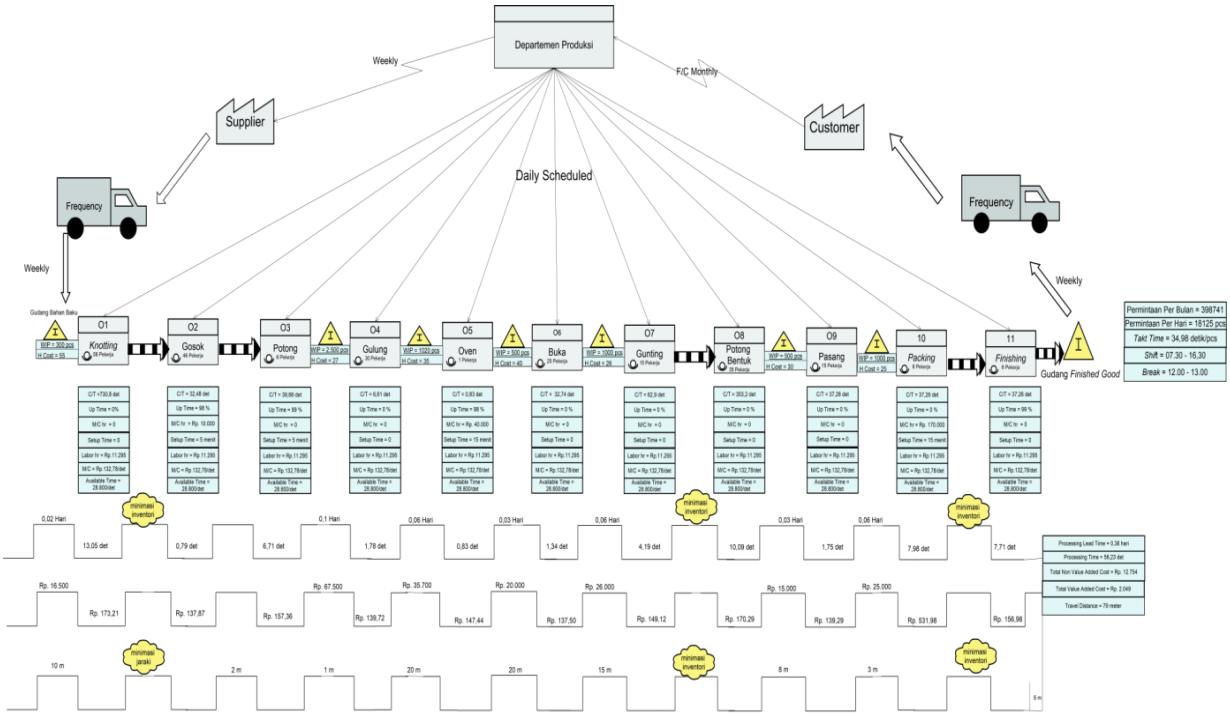

Figure 5. Future Cost Integrated Value Stream Mapping

The change from current cost-integrated value stream mapping to future cost-integrated value stream mapping through several stages is carried out by determining waste, identifying and reducing waste, then determining improvement proposals based on selected waste improvements, namely continuous flow, job combination, and delivery of raw materials. The information displayed in the visualization of figure 4 is a change from current to future mapping, as can be seen, one of which is the decrease in non-value added cost to IDR 11,243.

6. Comparative Analysis of Current and Future

The following is a comparison between current integrated value stream mapping and future integrated value stream mapping, which can be seen from table 6.

Table 6. Comparative Analysis of Current, Future and Improvement

Difference	Production Lead Time	Total VAC	Total NVAC	Travel Distance
Current	0,5 Day	IDR 2.049	IDR 12.754	99 m
Future	0,36 Day	IDR 1.561	IDR 11.243	79 m
Improvement	0,14 Day	IDR 488	IDR 1.511	20 m

4. CONCLUSION

Based on the data processing and analysis in this study, it was determined that the three waste types that became a barrier in the production of fake eyelashes were defect products with a percentage of 23%, waiting processes with a percentage of 16%, and inappropriate processing with a percentage of 16.%. The cause of the root cause of waste from the three most dominant wastes, namely careless operators, machines, and workers, was also determined to be less careful operators, machines, and workers. The production lead time is decreased from 0.5 days to 0.3 days as a result of the comparison between current cost integrated value stream mapping and future cost integrated value stream mapping. Additionally, the total value added cost is decreased from 2,049 to 1,561 and the total non-value added cost from 12,754 to 11,243. Finally, the travel distance is decreased from 99 meters to 79 meters. On the basis of future integrated value stream mapping, recommendations for improvement from this research include applying continuous flow in the knotting process to the rubbing process and in the scissors to cut form process by adding a trolley. Implementing work combinations from the packing to the finishing processes and switching from monthly to weekly supplier deliveries. Implementing preventative maintenance, creating inspection checklists, attaching work instructions to each workstation, creating maintenance SOPs, and ultimately emphasizing the value of work discipline to employees are all recommendations for reducing waste.

The authors' data processing and analysis yielded a number of recommendations for the future, among them the hope that this research's application of lean manufacturing will increase the company's productivity in the long run and that, for future research, the recommendations for improvement will be implemented as a form of continuous improvement. The application of integrated value stream mapping from continuous flow, which is necessary to achieve line balance throughout the whole production process, and recommendations for improvement are only a few of the many deficiencies from this research that still exist. Thus, it needs to be created.

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