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Implementation of Lean Manufacturing Approach Using Value Stream Mapping to Optimize Cycle Time and Reduce Process Waste (Case Study: CV. Teguh Jaya Mandiri)

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A B S T R A C T

Competition in several service sector companies and the manufacturing industry is getting tighter, which requires service companies as well as manufacturing to increase their production. Solving this problem can be started by improving the company system. Especially in minimizing or eliminating waste from the production process. CV. Teguh Jaya Mandiri is a company engaged in packaging screen printing services, its current condition has obstacles in the processing period that exceeds the time limit and does not match consumer demand. This is because the company has not done a good analysis in calculating the cycle time that occurs during the entire process. Thus, researchers can identify the level of waste and proposed improvements to optimize cycle time and reduce waste in the production process. In this research, the lean manufacturing method is used with the Value Stream Mapping tool followed by Process Activity Mapping which is one of VALSAT (Value Stream Analysis Tools). The results showed that Process Activity Mapping using the Value Stream Mapping approach identified waste in the production process at CV. Teguh Jaya Mandiri, namely there are overprocesses. The weighting result of overprocesses is 0,21. Cycle Time has decreased from 24812,5 seconds to 13908,5 seconds or 3 hours 52 minutes by eliminating NVA and reducing existing VA.

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1. INTRODUCTION

In the era of globalization, competition in the service and manufacturing sectors is becoming increasingly intense, driving companies to continuously enhance their production outcomes and quality (Kurniawan, 2020). Improvements can be achieved through company systems, product quality enhancement, human resources, and value-added activities. One way to enhance product value is by reducing waste in the production process (Komariah, 2022). The lean manufacturing approach can assist in reducing company losses and enhancing efficiency. Lean is a manufacturing practice that reduces waste during production, creating value. Value

Stream Mapping (VSM) is a manufacturing tool that visualizes the activities and functions of a company, including suppliers, production processes, and customer distribution (Maulana, 2019). This study examines CV. Teguh Jaya Mandiri, a packaging printing service company in Sidoarjo. Operating since 1992, the company receives short-deadline orders for packaging printing. The main challenges include a high number of defective products exceeding the company's 25% standard (Internal Company Data 2023). Contributing factors include human resource issues, careless material handling, and mismatches in materials. This research employs the Lean Manufacturing approach with Value Stream Mapping (VSM) and Process Activity Mapping to identify waste in the production process. Previous research results have demonstrated the success of this method in waste reduction (Silvia, 2021; Almunawir, 2022). Based on these aspects, the purpose of this study is to reduce waste and provide improvement suggestions for the production process at CV. Teguh Jaya Mandiri. This research is titled "Implementation of Lean Manufacturing Tools Value Stream Mapping for Cycle Time Optimization and Waste Reduction (Case Study: CV. Teguh Jaya Mandiri)" with the hope of offering appropriate alternative decisions. Using the value stream mapping method because previous research explains that the problem statement regarding production process waste, the results obtained through the Lean Manufacturing approach by Silvia (2021) show that lean manufacturing tools can be used to analyze and identify waste comprehensively from the manufacturing process flow that focuses on value-adding processes is Value Stream Mapping. Additionally, in the research by Almunawir (2022), waste obtained from Process Activity Mapping and Value Stream Mapping, namely delays identified through weighting, amounted to 0.18.

2. LITERATURE REVIEW

1. **Waste**
   Waste is defined as any form of activity in the process that does not add value from input to output (Fazzo et al., 2017). There are generally seven types of waste in the Toyota production system, namely overproduction, waiting, transportation, inappropriate processing, unnecessary inventory, unnecessary motions, and defects. Waste encompasses all work activities that do not add value to the transformation process from input to output along the value stream (Ridwan, 2020).
2. **Lean Manufacturing.**
   Lean Manufacturing has become a strategy for companies to attain various benefits, including enhancing production productivity, improving process efficiency in product manufacturing, reducing production costs to enable lower product prices, boosting product competitiveness, and meeting increased consumer demand. Therefore, the implementation of Lean Manufacturing methods is recommended for industries (Johan, 2022). Rochmah (2022) outlines several objectives of a lean production system aimed at reducing lead time and increasing output by eliminating waste in a company, which include: (a) Eliminating waste in the form of time, effort, and materials during the production process, (b) Producing products based on customer orders, and (c) Reducing costs while enhancing the quality of the resulting products.
3. **Value Stream Mapping**
   Value Stream Mapping (VSM) is a tool used to map the production and information flow for manufacturing a product from each workstation and planning for future states with improved performance (Suhardi et al., 2019). It serves as an initial step to identify the origins of waste in the production process and address issues. VSM considers and identifies issues from the arrival of raw materials from suppliers through various stages of the production process to the delivery of products to end customers. The utilization of Value Stream Mapping (VSM) for evaluation and improvement aims to minimize waste and enhance production process efficiency (Khunaifi, 2022).

   Research by Riyadi (2020), outlines the advantages of Value Stream Mapping as a tool for analyzing the mapping of production flow and information flow for manufacturing a product from each workstation. The advantages include: (a) Quick and easy creation, (b) No need for specialized computer software, and (c) Easily understandable. However, there are limitations to Value Stream Mapping: (a) Material flow analysis is limited to a single product or the same product type in one VSM, and (b) VSM is static and oversimplifies production floor issues.

4. **Process Activity Mapping**
   Process Activity Mapping is a technical approach used for activities on the production floor (Zuting et al., 2014). It can also be extended to identify lead time and productivity, both for physical product flow and information flow, not only within the company but also across the supply chain. The core concept involves mapping each activity stage, including operations, transportation, inspection, delay, and storage, categorizing them into types such as value-adding activities, necessary non-value-adding activities, and non-value-adding activities. The goal of this mapping is to aid in understanding process flow, identifying waste, assessing potential efficiency improvements, and pinpointing enhancements in value addition flow (Riyadi, 2020). PAM aims to reduce the activities of value-adding activities, necessary non-value-adding activities, and non-value-adding activities, and focuses only on specific operations that add value to products and services. In more detail, PAM provides average time and resource requirements for each activity within a specific process, which can be translated into costs for each particular (Batako, 2020).
5. **Borda Count Method**
   Borda Count Method (BCM), or simply Borda Method, is used to determine the best alternative from several options. Experts assign values to the alternatives, which are then converted into rankings. Decision-makers assign scores to these rankings, with the highest rank receiving a score of 1 and the lowest rank a score of 9. BCM overcomes limitations of other methods that automatically eliminate alternatives not in the top rank (Rozaq, 2019).
   In the Borda Method, each type of waste is ranked based on its frequency of occurrence, and these rankings are then weighted according to predetermined values derived from a sequence of second-level scores. Rank 1 carries the highest weight of (n-1), while rank 8 has the lowest weight of 0. The waste with the highest value is identified as the most frequent in the outpatient pharmacy installation process, referred to as a critical waste (Siti Feriani Rochimah, 2020).
6. **Root Cause Analysis**
   Root Cause Analysis (RCA) identifies and analyzes system failures to facilitate their resolution (Rizki, 2022). Commonly used RCA tools include (Benzon, 2022): (a) Pareto Diagram: A bar chart with a line graph depicting the frequency or cost of various problems, highlighting their relative significance. Bars show decreasing frequency, while the line indicates cumulative percentage as you move from left to right, (b) 5 Whys: This method involves asking a series of "why" questions to delve into a problem's layers and uncover its root cause. Each successive "why" is based on the previous answer. Deeper analysis can combine insights from Pareto analysis, (c) Fishbone Diagram (Ishikawa or Cause-and-Effect Diagram): Organizes potential causes into branching categories stemming from the original problem. Sub-causes branch from each identified category, (d) Scatter Plot Diagram: Plots problem causes (independent variables) on the x-axis and their effects (dependent variables) on the y-axis. This reveals relationships; clear line or curve patterns indicate correlation and can lead to correlation or regression analysis, (e) FMEA (Failure Mode and Effects Analysis): A proactive qualitative analysis tool used during process or product planning to identify potential systematic failure consequences and causes before events occur. FMEA assesses severity, occurrence, and detection levels, allowing the calculation of risk priority numbers for further action determination.

3. RESEARCH METHOD

In this study, the researcher selected the research location at the packaging screen printing service company CV. Teguh Jaya Mandiri, situated at Jl. Tambakoso Gg 1A RT.09 RW.03, Kampung Baru, Sidoarjo. This research was conducted from April 2023 until sufficient data were gathered.The following are the steps in this research (Figure 1).

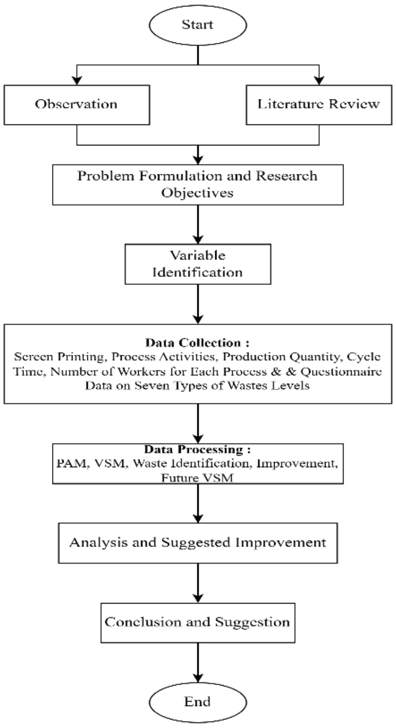

Figure 1. Research flow

Able to identify the level of waste and propose improvements for optimizing cycle time and reducing waste in the production process at CV. Teguh Jaya Mandiri.

4. RESULT AND DISCUSSION

4.1 Collection Data

Before processing the data, the initial step that needs to be taken is collecting data related to the research object. The data collection for the study includes secondary data from CV. Teguh Jaya Mandiri. The required data for addressing the issue includes general company overview, vision and mission, organizational structure, production processes, and production outcomes. Data collection is carried out through interviews with company management.

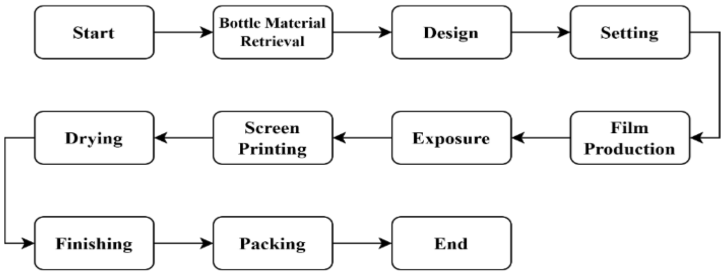

Figure 2. Flow process

Summary of Production Process at CV. Teguh Jaya Mandiri: The initial stage begins with the receipt of orders from customers. Acquisition of glass bottle materials according to customer orders. Determination of packaging design, based on customers or target market. Adjusting the design size on the frame for the next process. Creation of stencil film to transfer the image onto the screen. UV light exposure for the stencil process on the screen. Semi-automatic screen printing with design frame adjustment. Natural drying of glass bottle stencils. Finishing stage with quality check and baking for durable stencil results. Final packing process according to customer orders.

4.2 Data Processing

1. Production Process Cycle Time

   After observing each process of screen printing production activities and conducting the Data Adequacy Test and Data Uniformity Test, the data is deemed sufficient and consistent, proceeding to the next process, namely cycle time. The cycle time can be seen in the table below.

   With the following manual calculation:
   Total Time (seconds)
   = Average Time B1 + Average Time B2
   = 11370 + 23.5
   = 11393.5 seconds

Table 1. Production process cycle time

Process	Activity	Code	Average Time (Sec)	Total Time (Sec)
Glass Bottle Material Retrieval	Retrieval of Glass Bottle Material	A1	11.2	11.2
Design	Designing the stencil using Corel Draw	B1	11370	11393.5
	Transition to the setting section	B2	23.5	
Setting	Adjusting the design on the printing frame	C1	184.8	184.8
Film Creation	Creating a film as a reference for screen printing	D1	5792.2	5807.5
	Moving to the printing process section	D2	15.3	
Printing (Afdruk)	Painting the film frame to be used	E1	483.8	2309.6
	Drying the frame after painting	E2	1803.7	
	Moving to the screen printing section	E3	22.1	
Screen Printing (Sablon)	Attaching the design frame to the printing tool	F1	1788.1	2189.9
	Screen printing on glass bottles according to the design	F2	391.9	
	Moving to the drying section	F3	9.9	
Drying	Drying the screen-printed results	G1	842.1	853.7
	Moving to the finishing section	G2	11.6	
Finishing	Checking the screen-printed results	H1	496.4	1089.2
	Performing baking process for finishing	H2	582	
	Moving to the packing section	H3	10.8	
Packing	Packaging glass bottles according to customer requests	I1	973.1	973.1

2. Process Activity Mapping
   Process activity mapping provides an overview of the physical and information flow, as well as the time required for each activity in each production stage. The ease of activity identification occurs due to the categorization of activities into five types: operation, transportation, inspection, delay, and storage.

Table 2. Process activity mapping

Code	Average Time (second)	Activity					VA/NVA/ NNVA
		O	T	I	S	D	
A1	11.2		T				NNVA
B1	11370	O					VA
B2	23.5		T				NNVA
C1	184.8					D	NVA
D1	5792.2	O					VA
D2	15.3		T				NNVA
E1	483.8	O					VA
E2	1803.7					D	NVA
E3	22.1		T				NNVA
F1	1788.1					D	NVA
F2	391.9	O					VA
F3	9.9		T				NNVA
G1	842.1					D	NVA
G2	11.6		T				NNVA
H1	496.4			I			VA
H2	582					D	NVA
H3	10.8		T				NNVA
I1	973.1	O					VA

Description:

O = Operation
T = Transportation
I = Inspection
S = Storage
D = Delay
VA = Value Added
NNVA = Non Necessary Value Added
NVA = Non Value Added

Based on the above Process Activity Mapping, the cycle time calculation and the percentage of each activity are obtained, grouped based on the activities above it. As shown in the Table 3.

Table 3. Total production time for glass bottle screen printing

Activity	Total	Total Time (Sec)	Percentage
Operation	5	19011	76,62%
Transport	7	104.4	0,42%
Inspection	1	496.4	2%
Storage	0	0	0
Delay	5	5200.7	20,96%
TOTAL		**24812.5**	**100%**
VA	6	19507.4	78,62%
NNVA	7	104.4	0,42%
NVA	5	5200.7	20,96%
TOTAL		**24812.5**	**100%**

3. Value Stream Mapping
   In value stream mapping, there is information regarding the aspects of the screen printing production process at CV. Teguh Jaya Mandiri, allowing us to visualize the screen printing production process in its current state during direct observation (current) through a current value stream mapping diagram. The following Figure 3 is an illustration of the current value stream mapping.

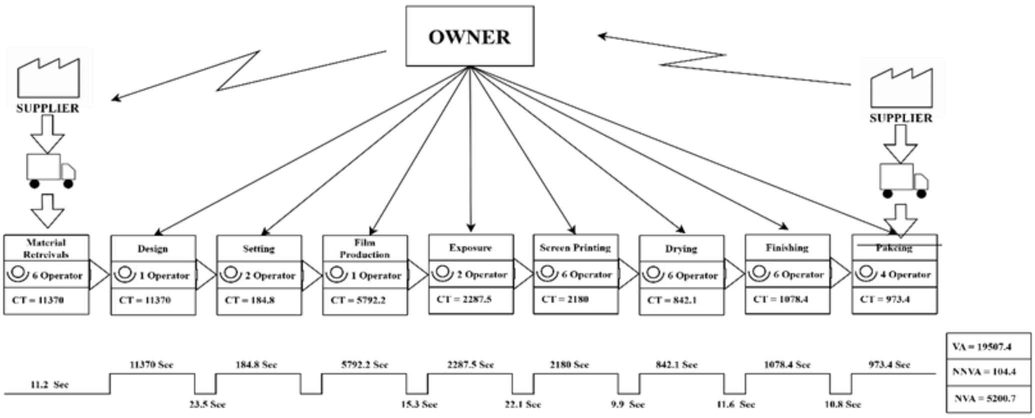

Figure 3. Current value stream mapping

Based on the current value stream mapping shown in Figure 4.4, it can be determined that the available time is 28,800 seconds with a total cycle time of 24,812.5 seconds or 6 hours and 53 minutes for each production cycle. In addition to illustrating the flow of the production process, the current value stream mapping also depicts several wastes that occur in the production proces.

4. Waste
To determine the weighting of waste, the researcher created a questionnaire distributed to several employees at CV. Teguh Jaya Mandiri. The weighting is done using the Borda method, where explanations for each type of waste are provided, and rankings from 1 to 5 are assigned. A ranking of 1 indicates the highest priority, while 5 indicates the lowest.

Table 4 Result of ranking calculation

Types of Waste	Rating				
	1	**2**	**3**	**4**	**5**
Overproductions	2		1	2	1
Delay	1	2		1	2
Transportation	1	2	1	2	
Processes	4	1	1		
Inventories	2		1		3
Motions		3	2	1	
Defect	2	2	1		1

Then the calculation is performed as shown in the example below:

- Ranking *Overproduction*
$= (2x4) + (0x3) + (1x2) + (2x1) + (1x0)$
$= 12$
- $\text{Weight} = \frac{\text{Ranking } overproduction}{\text{Total Weight}}$
$= \frac{12}{98}$
$= 0{,}12$

Table 5. Summary

Waste	Rating					Ranking	Weight
	1	**2**	**3**	**4**	**5**		
Overproductions	2		1	2	1	12	0,12
Delay	1	2		1	2	11	0,11
Transportation	1	2	1	2		14	0,14
Processes	4	1	1			21	0,21
Inventories	2		1		3	10	0,1
Motions		3	2	1		14	0,14
Defect	2	2	1		1	16	0,16
Weight	**4**	**3**	**2**	**1**	**0**	**98**	

Based on the weight graph of the waste above, it can be concluded that over processing is the most frequently occurring waste in the screen printing process of glass bottle packaging production at CV. Teguh Jaya Mandiri, with a weight of 0.21. Since the over processing waste has the highest weight rank, it requires more attention to be minimized.

5. Identifying Waste Causal Factors
From the identification results of the researcher on the screen printing production process of glass bottles at CV. Teguh Jaya Mandiri, the largest waste is in the form of over processing. For the improvement of the over processing waste, the 5 Whys root cause analysis tool is applied to the screen printing process of packaging at CV. Teguh Jaya Mandiri. Identification of the root cause of the issue in the process is necessary, thus the identification of the root cause is carried out using fishbone diagram and 5 Whys. The fishbone diagram helps visualize the root cause or its possibilities. The following is the waste analysis that occurs at CV. Teguh Jaya Mandiri using the fishbone diagram:

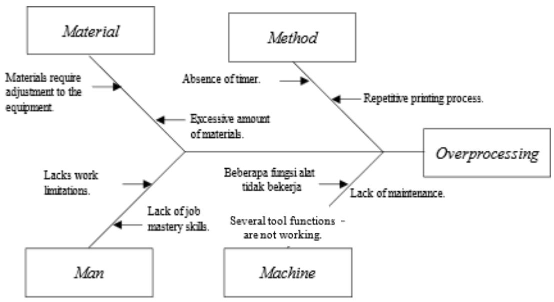

Figure 4. Fishbone diagram overprocessing

Through analysis and using the 5 Whys method, the factors causing each waste were identified. As a result of the analysis and interviews, a solution for overprocessing was proposed, involving the implementation of a policy by CV. Teguh Jaya Mandiri. The following suggestions aim to assist the company in making informed decisions to minimize non-value-added activities and streamline the cycle time of the glass bottle labeling production process.

Table 6. 5 Whys analysis

Process	*Why* 1	*Why* 2	*Why* 3	*Why* 4	*Why* 5
***Over processing* (VA) Desain**	Need for customer approval	Need for lengthy brainstorming	Lack of equipment specifications	The design created does not match the material	Frequent design revisions from customers
***Over processing* (VA) Pembuatan *Film* sablon**	Intermittent availability of film material	The film printing process takes a considerable amount of time	Finished film not meeting requirements	The film results have defects	Low-quality film material
***Over processing* (VA) Afdruk**	Color mismatch or painting errors	Excessive paint during the frame painting process	Mismatched positioning of film and frame	The frame material needs cleaning	Inappropriate frame selection
***Over processing* (VA) Sablon**	Repetition of screen printing processes	Lack of operator skills.	Empty screen printing ink requiring a refill.	Placement of material not in proper tool position	Malfunctioning tool components like pusher
Over processing* (VA) *Packing	Packing with bottle inspection	Packing requirements not prepared in advance.	Operator taking on two tasks simultaneous-ly.	Insufficient number of operators	Products missing in the packing area

6. Improvements
   Proposed improvements aim to reduce the most dominant waste identified through Borda method weighting in the glass bottle screen printing production process. The goal is to streamline the production process to achieve a more efficient cycle time, ensuring effective operations. The focus of improvement is on addressing over processing. The following suggestions are intended to assist the company in decision-making to minimize non-value-adding activities and streamline the cycle time of the glass bottle screen printing production process.

Table 7. Summary of Improvement

Activity	Process	Problem	Improvement
***Over processing* (VA)**	**Design**	Designing the glass bottle packaging requires a significant amount of time for its completion.	Providing a detailed and customer-specific design brief can help streamline the design process and improve efficiency.
***Over processing* (VA)**	**Screen Printing Film Creation**	Repetitive activities occur due to film detachment and unusability.	Selecting high-quality film material and ensuring consistent availability can mitigate this issue.
***Over processing* (VA)**	**Screen Printing Setup**	Exceeding the specified painting limit results in the need for cleaning and repainting	Enhancing workers' precision and skills in the painting process can address this challenge.
***Over processing* (VA)**	**Screen Printing**	Inefficient packaging screen printing due to lack of worker skills.	Providing training to workers to enable them to perform screen printing efficiently.
***Over processing* (VA)**	***Packing***	Workers multitasking while packaging glass bottles, coupled with the absence of products in the packing area.	Increasing the number of workers to prevent multitasking and ensuring equipment proximity to the corresponding activity.

Subsequently, improvements to the Process Activity Mapping (PAM) based on the aforementioned suggestions can serve as the foundation for enhancing PAM. In the Process Activity Mapping (PAM), the proposed improvements involve reducing cycle time by eliminating Non Value Added (NVA), namely delay, and minimizing Value Added (NNVA), which is operation. Below are the outcomes of the proposed improvements to the Process Activity Mapping (PAM).

Table 8. PAM improvements

Code	Average Time (second)	Activity O	T	I	S	D	VA/NVA/NNVA
A1	11.2		T				NNVA
B1	11370	O					VA
B2	23.5		T				NNVA
C1	184.8					D	NVA
D1	5792.2	O					VA
D2	15.3		T				NNVA
E1	483.8	O					VA
E2	1803.7					D	NVA
E3	22.1		T				NNVA
F1	1788.1					D	NVA
F2	391.9	O					VA
F3	9.9		T				NNVA
G1	842.1					D	NVA
G2	11.6		T				NNVA
H1	496.4			I			VA
H2	582					D	NVA
H3	10.8		T				NNVA
I1	973.1	O					VA

Based on the above table, it can be determined which activities add value and which do not. The data for the process improvement time of the screen printing production process can be seen in the Table 10.

Description:
= Activities that need to be reduced. (yellow)
= Activities that need to be eliminated. (red)

Table 9. Cycle time improvements

Activity	Total	Time Total (s)	Percentage
Operation	5	13307.7	95,68%
Transport	7	104.4	0,75%
Inspection	1	496.4	3,57%
Storage	0	0	0
Delay	0	0	0
TOTAL		**13908.5**	**100%**
VA	6	13804.1	99,25%
NNVA	7	104.4	0,75%
NVA	0	0	0
TOTAL		**13908.5**	**100%**
CYCLE TIME		13908.5	

The changes that occurred include a decrease in the total time of operation activities from 19,011 seconds to 13,307.7 seconds. Furthermore, the elimination of delay activities reduced the total time from 5,200.7 seconds to 0 seconds. With the reduction in time for each of these activities, the total production time changed from 24,812.5 seconds to 13,908.5 seconds. An analysis of the redesigned improvements for some of the time-reduced activities is provided in the Future Value Stream Mapping, as shown in the figure below.

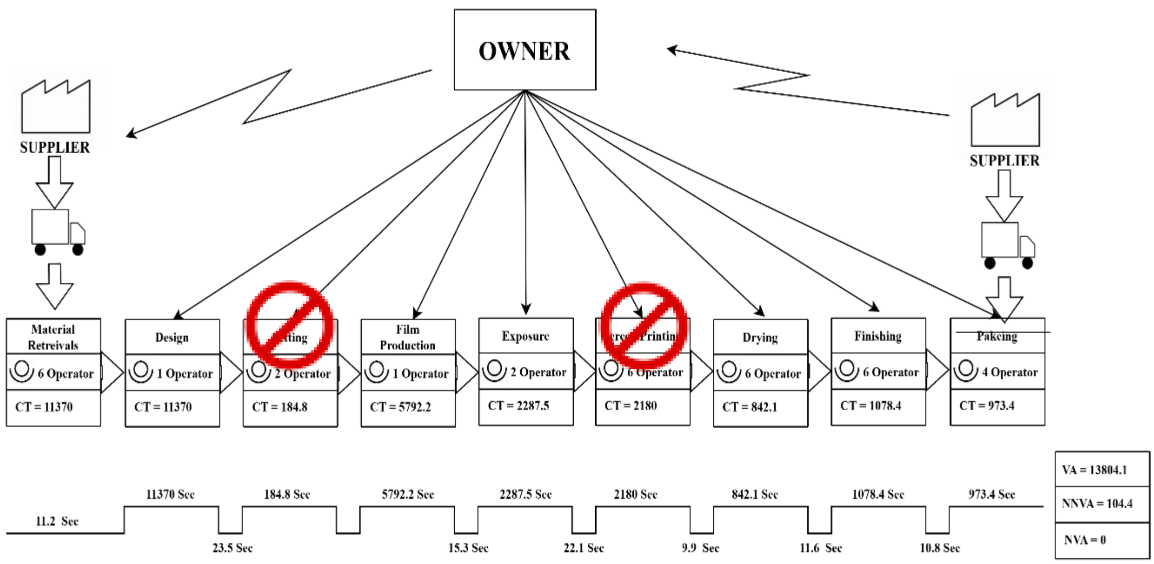

Figure 5. Future value stream mapping

= Eliminated Process

The Future Value Stream Mapping image above represents the overview of the glass bottle screen printing process at CV. Teguh Jaya Mandiri after the improvements were implemented. The Value Stream Mapping (VSM) will undergo changes due to the improvements made with policies that result in a reduction of cycle time from 24,812.5 seconds to 13,908.5 seconds, equivalent to 3 hours and 52 minutes.

The industry can utilize the results of this research by implementing the Lean Manufacturing approach, particularly the Value Stream Mapping (VSM) and Process Activity Mapping (PAM) methods, to identify and reduce waste in the production process. By understanding the existing wastes and implementing the proposed improvements, the industry can enhance production process efficiency, reduce cycle times, and optimize resource utilization. The outcomes of this research offer concrete and strategic guidance for the industry to design sustainable improvements that can lead to enhanced quality, productivity, and competitive advantage.

5. CONCLUSION

The following are the conclusions of this research:

In the glass bottle screen printing production at CV. Teguh Jaya Mandiri, two waste issues, overprocessing and delay, were identified through the analysis of the Current State Value Stream Mapping. Prioritization of waste was determined using a Borda method questionnaire, revealing overprocessing as the top concern with a score of 0.21. To address overprocessing, steps like setting, afdruk, sablon, drying, and finishing were removed as Non Value Added (NVA) activities, while Value Added (VA) steps were optimized, including afdruk cycle time, screen printing for packaging designs, and packing based on customer requests. The Future Value Stream Mapping design resulted in a cycle time reduction from 24812.5 seconds to 13908.5 seconds (3 hours and 52 minutes), achieved by eliminating Non Value Added (NVA) activities and reducing Non Value Added (VA) activities within the process. For future research, it would be valuable to delve into broader aspects of Lean Manufacturing beyond waste reduction, assessing its impact on overall production metrics. Exploring the application of various Lean tools, digital technologies, and automation for enhancing efficiency and waste reduction could yield practical insights. Comparative studies across industries could offer transferable best practices for optimizing processes and minimizing waste in diverse manufacturing settings.

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