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Application of Lean Analysis Value Stream Mapping to Minimize Waste: ACase Study of CV Jeans Gallery, Indonesia

Ruchbandi Rahmat T. Yasin, Stella Junus*, Rudolf Simatupang

Departement of Industrial Engineering, Universitas Negeri Gorontalo, Jl. Prof. Dr. Ing. B. J. Habibie, Moutong, Tilongkabila, Kabupaten Bone Bolango 96119, Gorontalo, Indonesia

*Correspondence: stellajunus@ung.ac.id

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ABSTRACT: CV Jeans Gallery is a convection company that faced significant challenges related to waste in its production process, including high waiting times, workload imbalances, and inefficiencies in production flow. The primary aim of this study was to identify and reduce waste through the application of the Value Stream Mapping (VSM) method. VSM was employed to map the production process, identify non-value-added activities, and uncover opportunities for improvement to enhance overall efficiency. Data was collected through direct observation, interviews with employees, and recording the time taken for various production processes. The analysis revealed that several types of waste occurred across the production stages. This included inventory waste, characterized by excessive raw material stock, and waiting waste, particularly during the design of embroidery patterns, where delays were frequently observed. Additionally, defects were identified as another significant form of waste, occurring when products could not be used by customers due to quality issues.

KEYWORDS: VSM; lean manufacturing; production efficiency; waste reduction; process optimization.

1. Introduction

Industry is an activity that involves a set of processes, including the processing of finished, raw, and semi-finished goods. These processes are carried out to add value to the goods [1]. Industries are divided into service and manufacturing industries. The service industry is an activity that provides goods or services to consumers through work. Examples of businesses in the service industry include transportation, banking, finance, stock exchange, healthcare, trade, telecommunications, tailoring, law, beauty salons, barbers, and goods delivery services. Meanwhile, the manufacturing industry involves activities that convert unfinished and semi-finished goods into finished products. Examples in the manufacturing industry include the food and beverage industry, pharmaceutical industry, chemical industry, metal and machinery industry, textile and clothing industry, automotive industry, and electronics industry.

CV Jeans Gallery is a business engaged in manufacturing, specifically clothing (convection). The products produced by CV Jeans Gallery include various types of clothing, such as Field Service Clothing (PDL), shirts, sweatshirts, vests, jeans, and denim jackets. The purchasing system at CV Jeans Gallery is based on a Pre-Order model. The Director of CV. Jeans Gallery explained in an interview that there are often leftover raw materials from the production of PDLs and T-shirts. The remaining materials for PDL production range from 1.5 to 2 kg from an order of 9-10 kg of raw materials, which cannot be processed further. The unused raw materials contribute to inventory waste. The Director also explained that waste occurs due to consumer dissatisfaction with product quality, resulting in defective products. Over the last 6 months, the Director reported that approximately 300 defective products were produced.

A workstation dedicated to sewing has six employees, but not all of them have expertise in sewing PDLs. Some of these six employees are only skilled in sewing other products, such as jeans and T-shirts. This causes waste due to waiting time, as the production process takes longer to complete. Another form of waste is Non-Limited Talent Waste, which occurs when employees' expertise does not match the job requirements. In CV Jeans Gallery's sewing section, some of the six employees are not qualified to sew all products, contributing to this type of waste.

The use of the VSM method in analyzing and reducing waste at CV Jeans Gallery is expected to make the production process more effective and efficient, aligning with the owner's goals. As a local garment industry player, CV Jeans Gallery has not been widely studied in the context of Lean and VSM implementation. However, the company faces various forms of waste, such as waiting time, overproduction, and defects, which can be identified and minimized using the VSM approach. Lean manufacturing, a concept developed by the Toyota company, aims to eliminate waste. Initially known as "Just-in-Time," the concept was later referred to as Lean Manufacturing. According to the Association for Operations Management, Lean focuses on reducing non-productive resources in products [2]. The goal of Lean manufacturing is to eliminate waste, allowing companies to become more effective, efficient, and competitive. Another objective of this concept is to reduce total lead time and eliminate waste [3].

Waste is any activity that does not add value to the production process [4]. According to Suhartono, in the Toyota Production System (TPS), eight types of waste occur in production activities: defects, overproduction, waiting, non-limited talent, transportation, inventory, motion, and excess processing. VSM is a tool in Lean Manufacturing that identifies waste by visually mapping the production process, allowing companies to target specific waste for elimination. The goal of using VSM is to achieve the most efficient lead time [5]. Additionally, VSM is an integral part of quality management, helping companies implement improvements [6].

2. Methods

The application of value stream mapping to determine waste requires the calculation of cycle time, lead time, changeover time, and takt time. The following is an explanation and how to calculate it. Cycle time, according to Rahma and Pratama, is the average time required to make 1 product, assuming that each process has a constant time when carried out [7]. The function of cycle time is to find out how fast the process in production can be completed. Here is the formula to determine cycle time [8]:

$$CT = \frac{production\ time}{output} \quad (1)$$

Where CT is Cycle Time, Production time is the time required for the production of one product, and Output is result of production (product).

Normal time is the time it takes workers to do the job. Normal time is obtained through the following calculation [9]:

$$WN = CTx\ (1 + pr) \quad (2)$$

Where WN is Normal Time, CT is Cycle Time, and pr is performance rating.

Standard time is the best time it takes each operator to complete the process and has been based on allowances. Here's the equation for finding standard time.

$$WB = WNx \frac{100\%}{100\% - \%allowance} \quad (3)$$

WhereWB is Standard Time, WN is Normal Time, %allowance is percentage of leeway.

Lead time is the total overall time that includes the time of activities that have value and those that do not. Lead time has four components, namely [10]:

PLT = processing time + waiting time + transportation hauling time + inspection time (4)

Takt time is the average unit of production time required to fulfill customer requests, the function of takt time is to become a company target in completing customer requests. The takt time calculation formula is as follows [11]:

$$Takttime = \frac{available\ working\ time}{customer\ demand} \quad (5)$$

Where Available working time is net time available for work, and Consumer demand is the amount of production required by consumers.

2.1.Data uniformity test.

Uniformity testing is determined through the following equation:

$$\underline{x} = \frac{\sum xi}{n} \quad (7)$$

Where $\underline{x}$ isaverage value of observation time, $\sum xi$ is total observation time, and n is totalobservations.

$$standarddeviation = \sqrt{\frac{\sum(xi - \underline{x})}{n-1}} \quad (8)$$

Where $\underline{x}$is average value of observation time, $n$is total observations, and $\sum$is total observation time.

$$BKA = \underline{x} + 2\sigma \quad (9)$$

$$BKA = \underline{x} - 2\sigma \quad (10)$$

Where BKA is Upper Class Limit, BKB is Lower Class Limit, $\underline{x}$is average value of observation time, and σ is standard deviation.

2.2.Data sufficiency test.

The data sufficiency test is determined through the following equation:

$$N' = \left[\frac{\frac{K}{S}\sqrt{Nx\sum x^2 - (\sum x)^2}}{\sum x}\right]^2 \quad (11)$$

Where N' is number of measurements required, N is number of measurements taken, X is observation time, S is Desired level of accuracy (in decimals), and K is confidence level.

The following are the confidence levels used in the data uniformity test: for a confidence level of 96% - 99% the price K = 3, for a confidence level of 69% - 95% the price K = 2, andfor a confidence level of 0% - 68% the price K = 1.

2.3.Observation time.

Observation time is obtained from observing the operation process of each process, starting from the pattern drawing process to the finishing process. The observation time is 30 times for each operation process (Table 1).

Table 1. Observation time of each production process at CV Jeans Gallery.

Observation	**Process time (minutes)**						
	Pattern drawing	**Pattern cutting**	**Basic sewing**	**Steam**	**Initial inspection**	**Embroidery**	**Finishing**
1	25	30	210	10	5	180	16
2	32	46	205	8	8	183	17
3	31	35	215	12	7	181	15
4	40	47	218	14	4	179	15
5	41	42	218	13	5	182	14
6	38	46	198	9	5	183	16
7	34	32	195	9	4	181	15
8	30	28	200	7	7	182	19
9	32	36	210	10	8	180	13
10	24	30	212	12	7	178	13
11	28	35	213	8	7	181	12
12	29	45	215	12	5	183	16
13	34	47	211	12	5	184	18
14	34	39	210	13	6	182	15
15	33	29	205	14	4	183	15
16	28	36	204	14	5	180	12
17	32	42	190	9	8	178	18

Observation	Process time (minutes)						
	Pattern drawing	Pattern cutting	Basic sewing	Steam	Initial inspection	Embroidery	Finishing
18	33	40	197	10	6	181	15
19	28	35	195	11	5	183	16
20	32	33	200	8	4	182	16
21	33	48	210	14	4	184	19
22	38	39	205	12	5	180	15
23	41	42	204	10	6	182	14
24	35	36	190	7	8	178	16
25	29	34	197	7	8	181	17
26	31	29	195	9	7	182	18
27	33	31	200	8	5	180	19
28	41	34	210	8	5	183	17
29	39	41	215	10	6	181	15
30	38	38	212	10	7	180	15
Total	**996**	**1125**	**6159**	**310**	**176**	**5437**	**471**

3. Results and Discussion

3.1. Results.

Mapping the current state aims to determine the production time and production flow. Thus, the current state mapping includes data on the information flow, material flow, number of operators, number of machines, and process time [15]. To create the current state mapping, several steps are necessary: determining the product model line, assigning a value stream manager, determining the standard time, creating a process category map, and drawing the current state map based on the research conducted at CV Jeans Gallery [16]. The following is an explanation of the steps involved in creating the current state mapping.Model line products are the focus of the research. In this study, the model line product is PDL at CV. Jeans Gallery. PDL products are the most popular products at CV Jeans Gallery, which is why they were chosen as the model line product for this research.A value stream manager is an individual who understands all the activities taking place at CV Jeans Gallery [17]. In this study, the researcher determined that the value stream manager at CV Jeans Gallery is the Director, Mr. FirmansyahMoito.Standard time is one of the key pieces of information needed to create a value stream [18]. Standard time includes stages for calculating cycle time, normal time, and standard time [19]. The following provides the standard time calculation for each process.

3.1.1. Data uniformity test results.

The determination of the cycle time in advance of the data that has been obtained is tested for uniformity and sufficiency of the data. And after testing the uniformity with equations (7, 8, 9, 10) the results of the data uniformity test can be seen on the control map graph (Figure 1). The result of the data uniformity test is that the process time is declared uniform because the process time does not exceed the minimum and maximum thresholds.

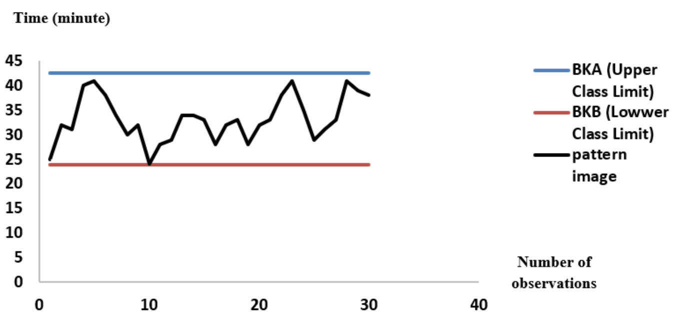

Figure 1. Time control map graph.

3.1.2. Data sufficiency test results.

The results of the data sufficiency test were calculated using equation (11) with an accuracy rate of 10% and a confidence level of 95%. Then, the results are obtained as shown in Table 2.

Table 2. Results of data uniformity and sufficiency testing

Process	Sufficiency test	Data uniformity test	Value
Pattern drawing	Simply	Uniform	7,63
Pattern cutting	Simply	Uniform	10,1
Sewing	Simply	Uniform	0,62
Steam	Simply	Uniform	18,81
Initial inspection	Simply	Uniform	21,48
Embroidery	Simply	Uniform	0,03
Finishing	Simply	Uniform	5,75

3.1.3. Process time.

After testing the uniformity and adequacy of the data and confirming that the data was sufficient and uniform, the cycle time was determined based on the observation time using Equation (1). The normal time was calculated using Equation (2), and the standard time for each process at CV Jeans Gallery was determined by considering the allowance time or percentage allowance, using Equation (3). The results are presented in Table 3.

Table 3. Recapitulation of cycle time, normal time, and standard time.

No.	Process	Cycle Time (minutes)	Normal Time (minutes)	% allowance	Standard Time (minutes)
1	Pattern drawing	33,2	38,18	27,00%	52,3
2	Pattern cutting	37,5	43,13	27,00%	59,07
3	Sewing	205,3	236,1	29,00%	332,52
4	Steam	10,33	11,88	26,00%	16,05
5	Initial inspection	5,87	6,75	26,00%	9,12
6	Embroidery	181,23	362,46	0,00%	181,23
7	Finishing	13,7	15,76	26,00%	24,39
	Total	**487,13**	**714,26**	**161,00%**	**674,68**

Figure 2 shows the current state mapping. We we can observe that the total production lead time, calculated using Equation (4), is 538.13 minutes, which represents the total waiting time until the product is completed. Based on the observation results, the activities were categorized into value-added, non-value-added, and necessary non-value-added activities. Table 4 presents the activities and their respective categories identified at CV Jeans Gallery.

3.1.4. Identification of waste.

Waste at CV. Jeans Gallery is categorized into several types, as detailed below. Inventory waste occurs due to the ordering of raw materials. For instance, when 9 kg of raw materials are ordered, 2 kg of raw materials remain unused after production of the PDL, leading to waste. Waiting waste arises during the redesign process when the embroidery design is done. The operator must adjust before proceeding to the next step of embroidering the PDL with the design specified by the customer, resulting in delays and inefficiency. Defective waste occurs when products do not meet the consumer's expectations. CV. Jeans Gallery offers a PDL ordering system where customers either provide custom body measurements or select a standard size (S, M, L, XL, XXL). However, defects often arise when the product does not fit the consumer properly, making the product unusable.The root causes of these wastes can be analyzed using a fishbone diagram. Figures 3 illustrate the fishbone diagrams for inventory, waiting, and defective wastes, respectively.

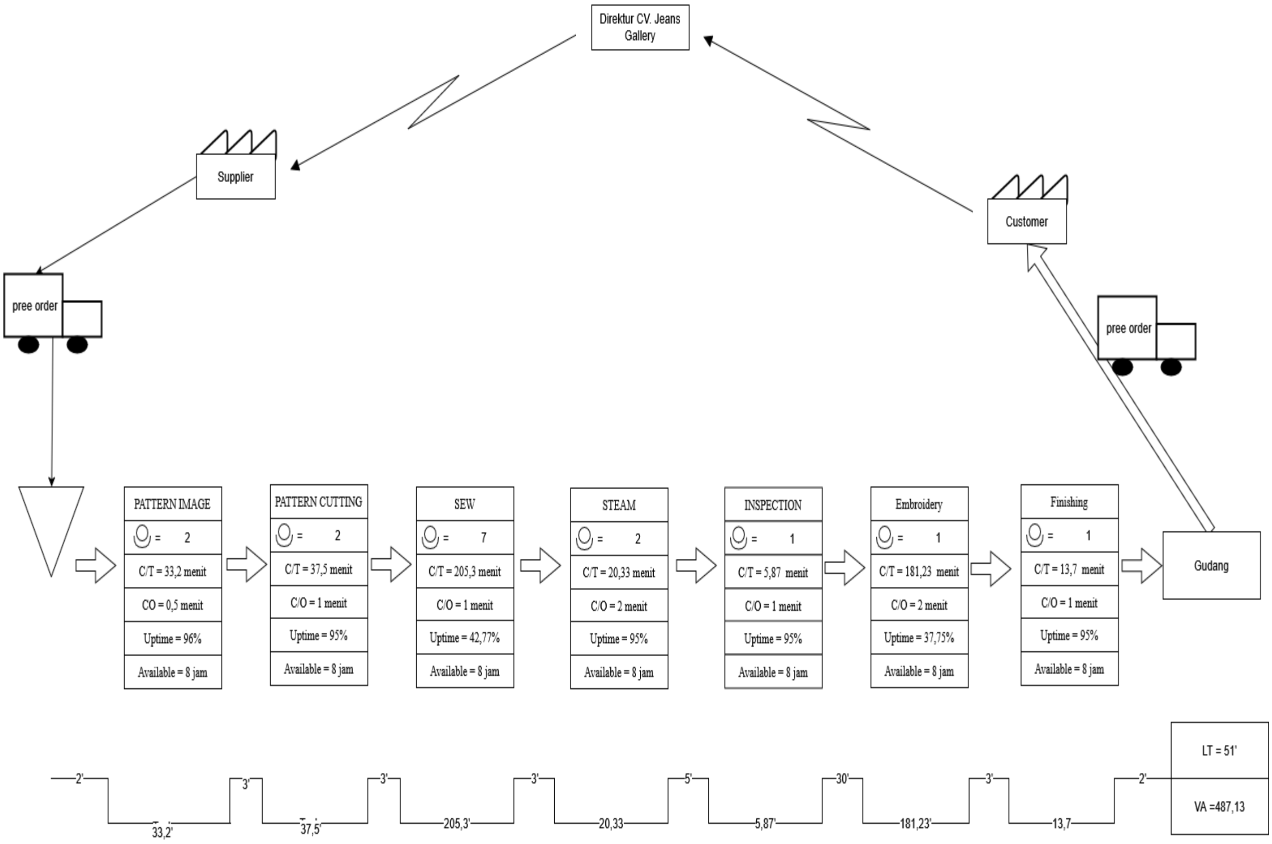

Figure 2. Current state mapping.

Table 4. VA, NVA, and NNVA activity groupings.

No.	Activity	Time (Minute)	Category
1	Fabric retrieved from warehouse	2	VA
2	Drawing patterns on fabric	33,2	VA
3	Cutting the pattern on the drawn fabric	37,5	VA
4	Transferring the cut fabric to the sewing section	3	VA
5	Attach the thread according to the color on the fabric	10	VA
6	Sewing pdl	195,3	VA
7	Transfer to the steam process section	3	VA
8	Heating up the steam appliance	2	VA
9	Steam pdl	18,33	VA
10	Moving to the inspection area	5	VA
11	Initial inspection	5,87	VA
12	Transferring to the embroidery section	2	VA
13	Making patterns for embroidery	30	NNVA
14	Embroidery	181,23	VA
15	Transfer to the finishing department	3	VA
16	Inspect the embroidery result	7	NNVA
17	Packing pdl	6,7	VA
Total		**545,13**	

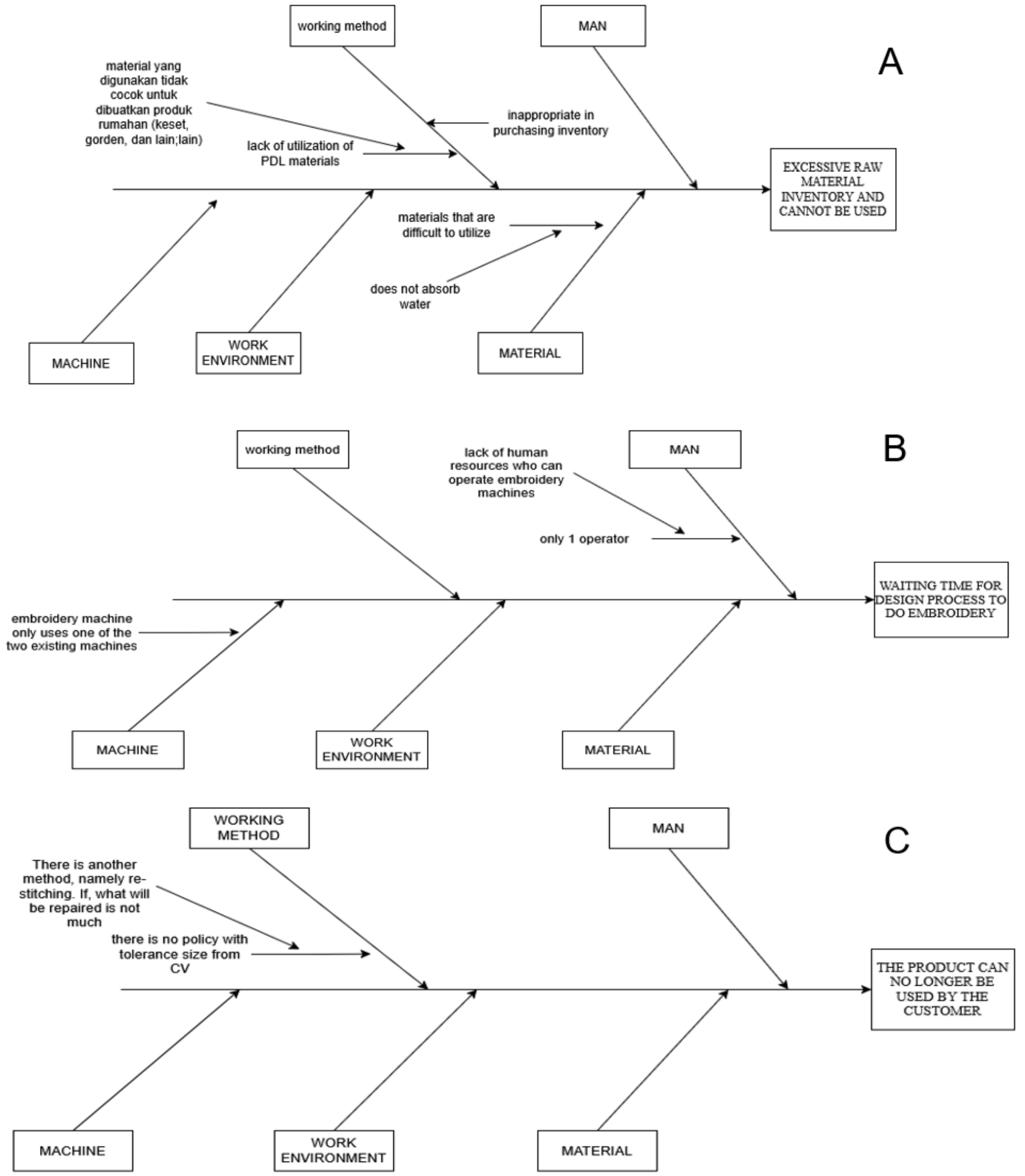

Figure 3. Fishbone diagram of waste of excessive and unusable raw material inventory (A), waste of products that cannot be used by customers (B), and waste of waiting time for the design process to bordit (C).

The fishbones in Figure 3A represent the problem related to inventory waste, specifically the excessive supply of raw materials. During the material analysis, the researcher identified the root cause: the raw materials used were difficult to utilize because they could not properly absorb water. The analysis of the working method revealed a lack of material utilization, which was caused by the unsuitability of the raw materials for use in other household products. This improper material utilization resulted in an excessive supply of raw materials. CV. Jeans Gallery's improper purchasing practices further contributed to this issue, leading to a large amount of leftover raw materials that could not be used due to the absence of a proper utilization method.

The fishbones in Figure 3B illustrate the problem of waiting waste, characterized by long waiting times during the design phase before the embroidery process. An analysis of human resources revealed that the waiting time in the production process, particularly in the embroidery stage, was largely caused by the fact that only one operator was assigned to the task. This shortage of qualified human resources to operate the embroidery machines at CV. Jeans Gallery resulted in prolonged waiting times, which ultimately affected overall production time. The analysis of the machines showed that CV. Jeans Gallery was not fully optimizing the available embroidery machines. Despite having two embroidery machines, underutilization led to increased waiting times and delayed product completion.

The fishbones in Figure 3C address the issue of defective waste. The primary defect identified was that products were unsuitable for customers due to sizing issues. CV. Jeans Gallery's policy allowed for product modifications through a "vermak" warranty, which aimed to accommodate the customer's body size. However, this process led to defects, as the products were not initially suitable for use by the customers.The takt time for each process was determined using Equation (5). After performing the calculations, the takt time for each process was summarized in Table 5.

Table 5. Recapitulation of takt time and cycle time.

No.	Process	Takt time (minute)	Cycle time (minute)
1	Pattern drawing	21,6	33,2
2	Pattern cutting	21,6	37,5
3	Sewing	21,6	205,3
4	Steam	21,6	10,33
5	Initial inspection	21,6	5,87
6	Embroidery	21,6	181,23
7	Finishing	21,6	13,7
	Total	**147**	**489,13**

Comparing the takt time with the cycle time, it can be observed that some processes have a lower takt time than the cycle time. A process time below the takt time indicates that the process is running faster and can meet the demand, meaning this process can be considered efficient. Conversely, when the process time exceeds the takt time, it indicates that the process is running slower than it should. Processes with cycle times above the takt time include pattern drawing, pattern cutting, sewing, and embroidery.The proposed improvements from the researcher for the three types of waste identified at CV. Jeans Gallery are as follows: For the defect waste type, the researcher proposed that CV. Jeans Gallery implement a policy regarding size tolerance when producing products to avoid the need for "vermak" (modification). This would eliminate the unnecessary repetition associated with product modifications. By establishing a size tolerance for products, CV. Jeans Gallery could avoid the looping process caused by product "vermak."For the waiting waste type, two proposals were suggested. Firstly, both embroidery machines should be utilized to speed up the production time. With the operation of both machines, the embroidery process would be faster, and the required number of products would be completed within the targeted time. The second proposal to address the long waiting time during the design creation phase is to establish a dedicated workstation for designing embroidery patterns. This would reduce waiting time during the transition between the initial inspection process and the embroidery stage.For the inventory waste type, the proposed improvement was to address the incorrect raw material inventory purchasing method. The researcher recommended implementing Economic Order Quantity (EOQ), Punctual Order Quantity (POQ), or other inventory control methods to manage inventory more efficiently.

3.2.Size.

Previous study reported that a total production process time of 294,388 seconds. Based on the results of FMEA, transportation was identified as the waste type with the highest RPN (Risk Priority Number) value. Proposed improvements included routine machine control, automation of the picking process, evaluation of production floor plans, and the implementation of the 5R culture (Sort, Set in Order, Shine, Standardize, Sustain) [20]. In contrast, this study focused on using takt time as a reference to determine the time required to produce one product unit per production process.

4. Conclusions

The application of the VSM method at CV Jeans Gallery successfully identified the main types of waste occurring in the production process, which include inventory waste, defects, and waiting times. These findings highlight areas where improvements are necessary to optimize production efficiency and reduce waste.Additionally, the implementation of the FMEA method revealed that defective waste is the most critical issue, with the highest Risk Priority Number (RPN) of 240. This high RPN value is a result of the severity, occurrence, and detection ratings, emphasizing the importance of addressing this issue. The root cause of defective waste is the lack of a clear policy regarding size tolerance, which results in the need for re-stitching (vermak) to correct minor defects. This rework process leads to wasted resources and, in some cases, products that cannot be used by the customer.To mitigate these issues, CV Jeans Gallery should implement a clear size tolerance policy to prevent defects and minimize the need for rework. Addressing the defects will improve product quality, reduce waste, and enhance customer satisfaction. Additionally, further improvements in inventory management and waiting times should be considered to ensure more efficient production processes.

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Author Contribution

Stella Junus: conceptualization, methodology, supervision; Ruchbandi Rahmat T Yasin: data collection, data analysis, writing, funding; Rudolf Simatupang: supervision.

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