Combination of value stream mapping (VSM) method and kanban system to reduce time waste in the production process of making parts for the four-wheel vehicle industry

Vebina Sheila Pasha[1]*, Jacky Chin[2]
[1] Industrial Engineering Master Study Program, Faculty of Industrial Engineering, Universitas Mercu Buana, Jl. Raya Meruya Selatan No. 1 Kembangan Jakarta, Indonesia
[2] Industrial Engineering Department, Faculty of Industrial Engineering, Universitas Mercu Buana, Jl. Raya Meruya Selatan No. 1 Kembangan Jakarta, Indonesia
* Corresponding author: vebinasheilap@gmail.com

ARTICLE INFO

Article history
Submission: 10th November 2023
Revised: 3rd June 2024
Accepted: 5th June 2024

Keywords
Increase Production
Kaizen
Re-layout
Reduce ProcessTime
Root Cause Analysis

https://doi.org/10.22219/oe.2024.v16.i1.104

ABSTRACT

Fulfilling orders from customers in the automotive industry is a necessity that inevitably causes problems that arise in product delivery to customers due to production delays and decreased production yields. The production process often experiences wasted time in the production process of four-wheeled vehicle spare parts. This research aims to reduce production process time, provide solutions to reduce waste and increase the number of four-wheeled vehicle spare parts produced. This research method uses the Lean Manufacturing (LM) approach by combining the Value Stream Mapping (VSM) method with Kanban system improvements, the application of Root Cause Analysis (RCA), and the Kaizen method. This research found that four factors cause waste in process time, including environmental factors, methods, humans, and machines. This research produces the right solution in the relay out of the Assembly and Final Inspection production processes, as well as the use of the e-kanban system in material and product inventory. The research results have reduced the production process time from 17.10 days to 10.05 days, meaning a decrease of 41.22%. This affected production results which increased from an average monthly production of 42,917 pcs to 60,157 pcs, meaning an increase of 128.65%.

1. Introduction

Indonesia, Thailand, Malaysia, and the Philippines are known as the ASEAN-4 cluster and the dominant automotive players in Southeast Asia. Based on the ASEAN Automotive Federation (2020), shows that the total production of four-wheeled vehicles in ASEAN reached 4,158,953 units in 2019. Indonesia is a country that is growing rapidly as an exporter of four-wheeled vehicles and is the world's leading automotive producer (Khan & Mushtaq, 2022). After starting vehicle assembly in the 1920s, for the first time, Indonesia produced more than 1 million vehicles. Thus making Indonesia the 17th largest vehicle producer in the world. Currently, competition is a challenge that continues to be faced by industrial companies, especially four-wheeled vehicle manufacturers. ASEAN Automotive Federation Indonesia is the largest car market in Southeast Asia and the ASEAN region, controlling around a third of total annual car sales in ASEAN, followed by Thailand in second place (Fig. 1).
Based on the data in Figure 1, shows that the automotive industry in Indonesia is growing rapidly, which indicates that the public's need for motorized vehicles is high. This will have an impact on business in the automotive manufacturing sector. According to research in Indonesia, 70% of respondents choose to use private vehicles more often. Four-wheeled vehicle manufacturers strive to

Please cite this article as: Pasha et al. (2024). Combination of value stream mapping (VSM) method and kanban system to reduce time waste in the production process of making parts for the four-wheel vehicle industry. *Operations Excellence: Journal of Applied Industrial Engineering*, 16(1), 76-89. doi:http://dx.doi.org/10.22441/oe.2024.v16.i1.104

continue to improve the efficiency of production systems by reducing Non-Value-Added (NVA) activities. Therefore, the large demand for four-wheeled vehicle products has an effect on the increasingly high supply of spare parts for four-wheeled vehicle production (Purba et al., 2018; Zulkarnaen et al., 2023).

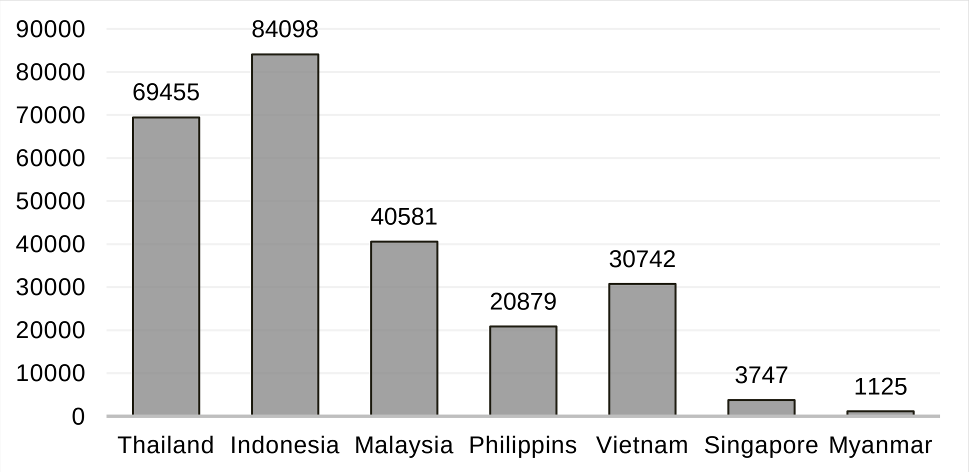

Fig. 1 Car sales in the ASEAN Region (source: Gaikindo 2021).

The automotive industry is one of the industries most actively involved in efforts to improve quality, productivity, labor efficiency, and continuous improvement activities (S. Setiawan et al., 2021). Several research studies demonstrate significant opportunities for increased efficiency in the automotive industry through the implementation and higher utilization rates of Lean Manufacturing (LM) (Aisyah et al., 2021; Nallusamy & Adil Ahamed, 2017). According to (Liker & Meier, 2006), waste is one of the biggest problems in the manufacturing industry. One way to identify waste is to use the Waste Assessment Analysis (WAA) method, namely by identifying the types of waste which include Non-Value Added (NNVA), Non-Value Added (NVA), and Value Added (VA) (Tannady et al., 2019). The advantage of this model is the simplicity of the matrix and research questions that cover many things and can contribute to reaching the right decisions in identifying the causes of waste. WAA is often combined with Lean methods as an improvement method (Aprianto et al., 2022). Lean is a Lean production concept that is suitable for creating effective and efficient production systems (Kurnia et al., 2022). The Lean approach can eliminate waste to improve manufacturing performance and Lean is an effective strategy for reducing waste (Jaqin et al., 2023). Wasted production time on the assembly line needs to be improved because continuous NVA activities must be reduced to a minimum, which will result in reduced waste of process time and increase production efficiency of four-wheeled vehicle spare parts.

Several studies related to Lean have had a big impact on the manufacturing industry, including reducing labor, reducing lead time, saving costs, increasing productivity, and increasing customer satisfaction (Castro & Riedel, 2017). In the production process in a company, some activities do not have added value or waste which will result in the use of resources ranging from energy, human resources, and time making the process inefficient (Ikatrinasari et al., 2018). One method for minimizing waste is Lean Manufacturing which functions as an effort to increase the efficiency of the production process and eliminate waste by identifying waste. Apart from that, one of the efforts made by the company to increase productivity is by using a just-in-time production system (B. Setiawan et al., 2022). The just-in-time method is a concept used in production activities to save production costs (Chiarini et al., 2018). There are several technical components of implementing Just in Time, namely: improving quality, reducing setup time, technology grouping, uniform workload, multi-functional workforce, company focus, Kanban, Total Productive Maintenance (TPM), Total Quality Control (TQC), and precise delivery time (Salvador et al., 2017). The Kanban system is a workflow method used to control the production process to increase the productivity of a company. Kanban is also used to identify products related to lean manufacturing and can improve inventory system design (Kurniawan et al., 2022).

Please cite this article as: Pasha et al. (2024). Combination of value stream mapping (VSM) method and kanban system to reduce time waste in the production process of making parts for the four-wheel vehicle industry. *Operations Excellence: Journal of Applied Industrial Engineering*, 16(1), 76-89. doi:http://dx.doi.org/10.22441/oe.2024.v16.i1.104

Other research in the automotive industry is related to reducing waste in production process time using the Waste Analysis Model, VSM, and Lean Automation methods (S. Setiawan et al., 2021). Meanwhile, this research has the novelty of eliminating wasted production process time in the Assembling and Final Inspection (FI) sections using the Lean Manufacturing (LM) approach by combining the Value State Mapping (VSM) method with improvements to the Kanban system, the application of Root Cause Analysis (RCA) and other methods. Kaizen. This research aims to reduce production process time, provide solutions to reduce waste and increase the number of four-wheeled vehicle spare parts produced.

2. Methods

This research was conducted at one of the automotive parts manufacturing companies with plastic injection molding production type located in the Delta Silicon 3 Lippo Cikarang industrial area, Bekasi Kanupaten, West Java. This company is engaged in manufacturing spare parts for four-wheeled vehicles in the automotive industry. The research time was only carried out for 1.5 years from July 2021 to December 2022. This type of research includes mixed method research by combining qualitative and quantitative approaches with a specific design to answer the research objectives (W Creswell, 2014). Primary data was obtained through direct observation to determine the production system and material flow for making four-wheeled vehicles. Meanwhile, secondary data generally takes the form of historical production data, attribute data, and other supporting data as a complement to research. The research steps can be seen in Fig. 2.

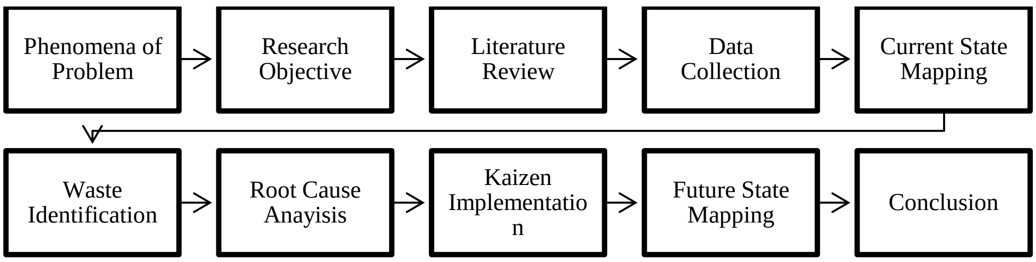

Fig. 2 Research stages.

Based on Fig. 2, the first step in this research is collecting data, either primary data through observation or secondary data through production reports. Then create a CSM diagram using the Visio application software, after that identify waste which includes NNVA, NVA, and VA activities. Once it is known that there is NVA activity, the next step is to make a root cause analysis to find out the problem analysis using why-why analysis and a 5W+1H improvement plan. Then make improvements by applying the Kaizen method of comparing before and after improvements. The final step is to create an FSM diagram using the Visio application software which is carried out after all corrective actions have been carried out by the improvement team.

3. Results and Discussion

In this section, the results of several steps that have been determined will be discussed, starting from data collection to evaluating the results of improvements.

3.1 Data Collection

In this section, we will discuss the flow of the process of making spare parts from various types of plastic injection for the needs of four-wheeled vehicle spare parts. The flow of the process for making four-wheeled vehicle spare parts can be seen in Fig. 3.
Based on Fig. 3, new bottles occur in the Assembly and Final Inspection (FI) section because a lot of stock has accumulated in that section. The stock of goods is piling up due to the delivery of goods from the previous process, namely the Steam Room (SR) using a truck with a capacity of 3,656 pcs while the Assembly process has a capacity of 2 pcs per Cycle Time (C/T). This imbalance in the stock of goods will result in an imbalance in the flow of the production process to the Finished Goods

Please cite this article as: Pasha et al. (2024). Combination of value stream mapping (VSM) method and kanban system to reduce time waste in the production process of making parts for the four-wheel vehicle industry. *Operations Excellence: Journal of Applied Industrial Engineering*, 16(1), 76-89. doi:http://dx.doi.org/10.22441/oe.2024.v16.i1.104

Warehouse (Mirzaei et al., 2021; Nuryono et al., 2024). This has resulted in an imbalance in the production process that has occurred so far. The production results for 2021 can be seen in Fig. 4.

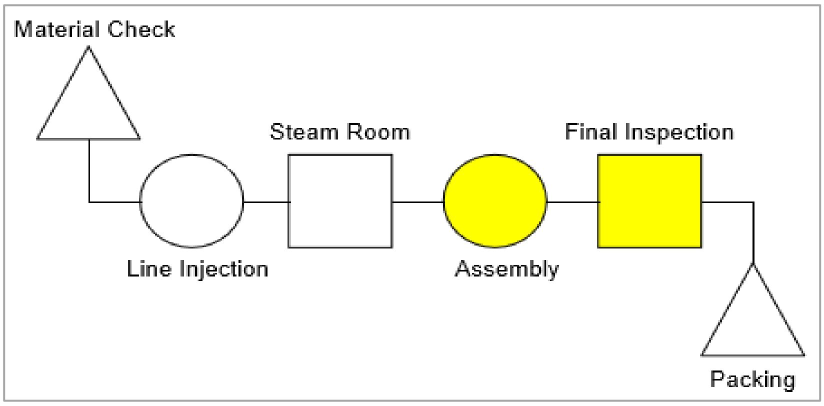

Fig. 3 Operation of the spare parts manufacturing process.

Based on Figure 4, the most dominant production result is the manufacture of spare parts with the PP125 type, amounting to 513,200 pcs. This PP125 type is a plastic injection part for body cover accessories for four-wheeled vehicles. Therefore, this PP125 part type will be used as research material in reducing the production process time for making four-wheeled vehicle spare parts. Products that become dominant in terms of production must remain under control of stock inventory to fulfill orders from customers (Kurnia, Jaqin, et al., 2021; Sjarifudin et al., 2022). The production results of PP125-type spare parts before improvements for 6 months can be seen in Figure 5.

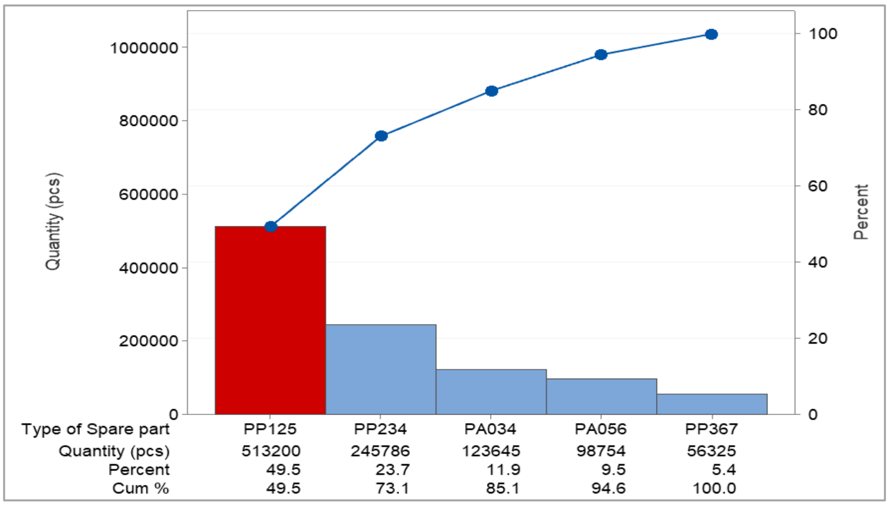

Fig. 4 Total Production of four-wheeled vehicle spare parts in 2021.

Based on Fig. 4, the most dominant production result is the manufacture of spare parts with the PP125 type, amounting to 513,200 pcs. This PP125 type is a plastic injection part for body cover accessories for four-wheeled vehicles. Therefore, this type of PP125 part will be used as research material in reducing the production process time for making four-wheeled vehicle parts. Products that become dominant in terms of production must remain under control of stock inventory to fulfill orders from customers (Kurnia, Jaqin, et al., 2021). The production results of PP125-type spare parts before improvements for 6 months can be seen in Fig. 5.

Based on Fig. 5, the average production of PP125-type spare parts for 6 months reached 42,917 pcs which were produced using the spare parts manufacturing process in Buildings 1 and 2. This achievement is still far from the production target of 55,000 pcs/month, so the production efficiency achieved only 78.00%. Good achievements from manufacturing companies can be seen in the achievement of efficiency every month, if they have not reached the efficiency target then continuous improvement is needed (Wiyatno & Kurnia, 2022).

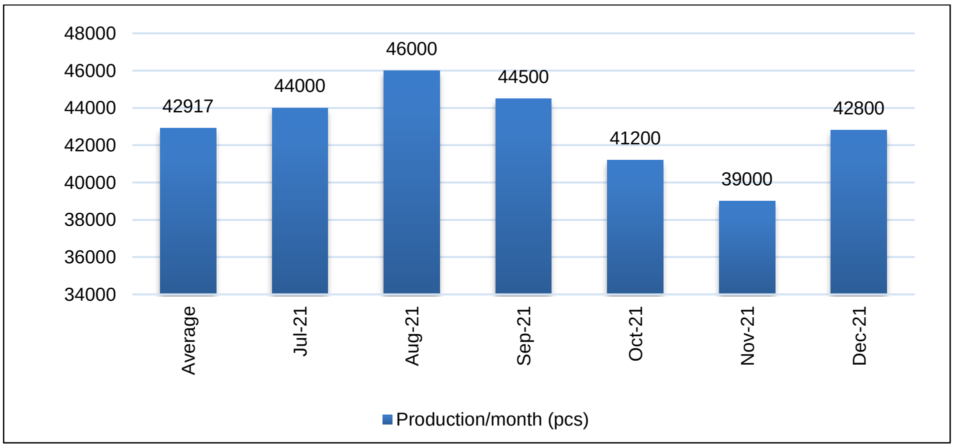

Fig. 5 Production of PP125 type plastic parts before improvement.

3.2 Current State Mapping (CSM)

In this section, the results of data processing will be discussed in the form of measuring process time before improvements using a CSM diagram. The results of the CSM diagram can be seen in Fig. 6.

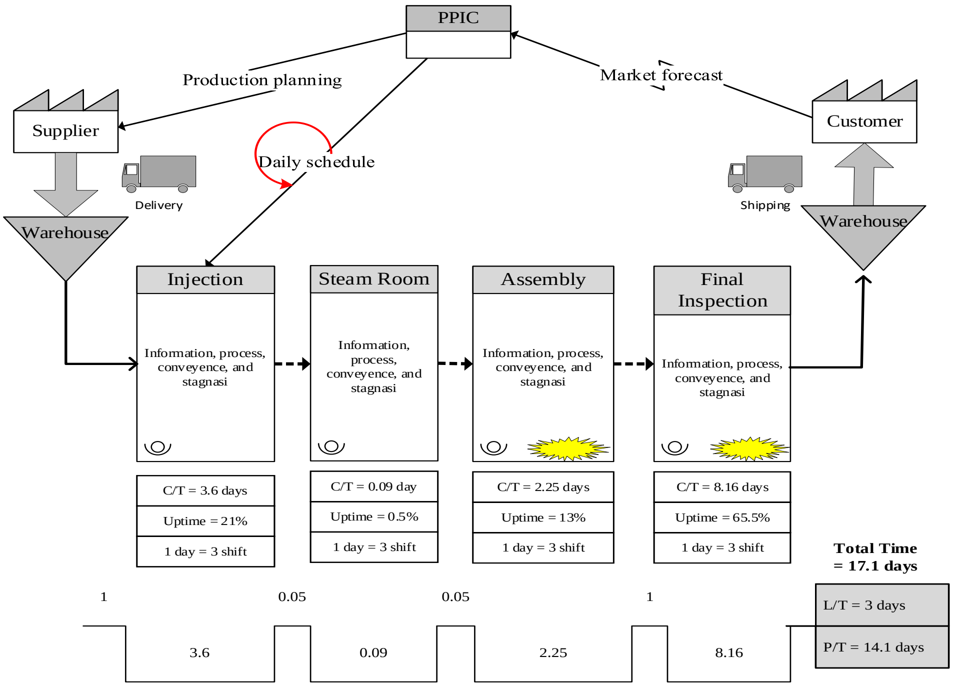

Fig. 6 Current state mapping diagram.

Based on Fig. 6, the results of time measurements before improvements are in the form of a CSM diagram related to the Lead Time (L/T) results of 3 days and Process Time (P/T) of 14.1 days, so the total production process time in 1 lot = 3656 pcs is 17.1 days. Calculation of L/T and P/T resulting from the start to finish process which is calculated based on all parts of both Building 1 and Building 2.

3.3 Waste Identification

In this section, we will discuss the results of data processing in the form of waste identification consisting of Value Added (VA), Non-Value-Added (NVA), and Non-Value-Added Necessary (NNVA). Identifying waste in several categories makes it easier to take future improvement steps that focus on activities that do not add value (Kurnia, Tumanggor, et al., 2021; Kurnia & Hardi Purba, 2021). The grouping of waste types based on process flow and waste categories can be seen in Table 1.

Table 1 Identification of Spare Parts Manufacturing Waste Before Improvement

Activity	Injection (days)	Steam Room (days)	Assembly (days)	Final Inspection (days)
Information	0.865		0.857	5.190
Process	0.239		0.000	0.002
Conveyance	0.008	0.054	0.013	0.038
Stagnasi	2.492	0.040	1.382	2.932
Total	3.605	0.094	2.252	8.163

Based on Table 1, the dominant production process time for making PP125-type spare parts is the Assembly production process of 2,252 days and Final Inspection (FI) of 8,163 days in the information waste and stagnation categories. Waste categories that do not have added value need to be improved in processing time, because it will affect efficiency (Rose et al., 2020). Therefore, in these two parts, it is necessary to group each activity which can be seen in Table 2.

Table 2 Classification of Spare Parts Manufacturing Waste

Process	Activity	Activity identification	Time (days)	Classification VA	NVA	NNVA
Assembly	Setting Machine	Waiting for information on the machine program	0.300		√	
		PPIC staff checks the product that will run	0.382			√
	Setting Product	Install the product on Jig, run the the process	0.557	√		
		Waiting to check the finished goods	1.000		√	
Final Inspection	Visual Check	Waiting for information on how many products to check	4.000			√
		Cleaning the product and improvement	2.932			√
	Wrapping	Wrapping the product	1.190			√
		Total	10.361 days	0.557 day	1.300 day	8.504 days

Based on Table 2, six identified activities do not have added value with a total NVA of 1,300 days and NNVA of 8,504 days. Identification of activities that do not have added value must be immediately addressed to improve them (Fam et al., 2018). This is to reduce wastage of production process time and can increase the amount of production for making four-wheeled vehicle spare parts.

3.4 Root Cause Analysis

In this section, we will analyze several issues identifying activities that do not have added value, thereby affecting the amount of production that has not yet reached the target. The problem analysis used in this research uses why-why analysis which can be seen in Table 3.

Table 3 Why-Why analysis of process time waste problems

No	Issue	Why 1	Why 2	Why 3	Why 4	Why 5
1	Waiting for information on the machine program	Continuous machine setting program from Building 1	The location of Building 1 is far away	Buildings 1 and 2 are far apart	-	-
2	PPIC staff checks the product that will run	PPIC staff checks	The inventory system is still an	There has been no change to the	-	-

No	Issue	Why 1	Why 2	Why 3	Why 4	Why 5
		manually on the Proxpro system	old system	inventory system		
3	Waiting to check the finished goods	Finish goods require a long inspection because it is 1 lot	Manual inspection	There is no comprehensive inspection system yet	-	-
4	Waiting for information on how many products to check	Number of products checked manually	Waiting for manual confirmation from superiors	No system can quickly provide decisions	-	-
5	Cleaning the product and improvement	Product inspection and improvement process	Before sending it to customers, make sure the product status is OK	As a quality assurance requirement	-	-
6	Wrapping the product	Wrapping using old machines	It takes time for the packaging process in lots	There has been no replacement for a new wrapping machine	-	-

Based on Table 3, the dominant problem is the waste of time in the production process of making 4-wheeled vehicle spare parts due to the long process time between Building 1 and Building 2. Apart from that, the inventory system is still manual so it takes a lot of time to analyze, provide information, and confirm the clarity of the status of the product (Sjarifudin & Kurnia, 2022). Therefore, it is necessary to plan comprehensive improvements using the 5W+1H method, which can be seen in Table 4.

Based on Table 4, four causal factors influence the waste of time in the process of making 4-wheeled vehicle spare parts. Environmental factors that provide layout conditions for the production process are carried out in two buildings. The method factor is that there is no fast system for providing information and decisions regarding product status. Human factors from PPIC staff who are late in the process of executing the product process flow, late in deciding the quality status of finished goods, and late in confirming the selection of products that must be cleaned and improvemented so they can be delivered quickly. The machine factor is that the old warping machine is still used which has a small capacity, namely 4 bundles. All contributing factors to the root of the problem that will cause problems must be planned and improvements implemented (Hidayat et al., 2021).

Table 4 5W+1H improvement plan

Factor	What	Why	Where	When	Who	How
Environment	Waiting for information on the machine program	Buildings 1 and 2 are far apart	Assembly area	Jan-22	Vendors and Technicians	Re-layout and transfer of Assembly machines to Building 1
Man	PPIC staff checks the product that will run	There has been no change to the inventory system	Production area	Feb-22	PPIC	Change of Proxpro system to Kanban system
Man	Waiting to check the finished goods	There is no comprehensive inspection system yet	Final Inspection area	Mar-22	QC	Use of an inspection system with the Kanban system

Factor	What	Why	Where	When	Who	How
Method	Waiting for information on how many products to check	No system can quickly provide decisions	Final Inspection area	Mar-22	QA	Use of an inspection system with the Kanban system
Man	Cleaning the product and improvement	Product inspection and improvement process	Final Inspection area	Mar-22	QC	Use of air gun and cleaning fluid
Machine	Wrapping the product	There has been no replacement for a new wrapping machine	Packing area	Apr-22	Packing	Use of new wrapping machines and wrapping per pallet

3.5 Kaizen Implementation

After the improvement plan has been carried out, this section will discuss the results of the Kaizen implementation that has been carried out. Kaizen implementation can be explained as follows:

a. Waiting for information on the machine program

Before: The machine settings are closely related to the previous program processed in Building One, so the next process waits for confirmation from the previous process.

After: Re-layout the Assembly and FI areas into one building so that the production process will be sustainable.

Kaizen remarks: Closer relaying of Assembly and Final Inspection production areas and a continuous production process can reduce lead time and process time more efficiently and effectively.

b. PPIC staff checks the product that will run

c. Waiting to check the finished goods

d. Waiting for information on how many products to check

Before: The old system used the Proxpro system which only provided manual input modules for incoming goods, processed goods, inventory correction, and stock taking. The information produced includes stock conditions, stock transfers/cards, transaction recapitulation, and Cost of Goods Sold (COGS) reports.

After: The new system uses a more complete Kanban system consisting of electronic modules for incoming goods, storage, returns, material processing, stock in the warehouse, re-processing, returns, stock taking, and materials and rejected products produced.

Kaizen remarks: Use of the Kanban system, both e-Kanban and manual, with information boards in the form of whiteboards and layer displays for information on production results, production defects, and stock. The production process runs smoothly, product confirmation of OK and NG status can be quickly known and the difference in stock-taking results is <1%. The Kanban system using Kanban cards can make it easier for operators to determine the next stock so that the material stock balance is achieved (Kurnia et al., 2023).

e. Cleaning the product and improvement

Before: Products that enter the FI section must be manually cleaned thoroughly to maintain product cleanliness.

After: Products entering FI are cleaned with soft gun water and cleaning fluid, thereby saving cleaning and improvement time.

Kaizen remarks: Cleaning of products entering FI is mandatory, using a cleaning tool using an airsoft gun can speed up the process to the next stage, namely wrapping. Cleaning is one of the improvements from Kaizen 5S so that when sorting goods it can make reading and subsequent conditioning easier (Saing et al., 2023).

f. Wrapping the product

Before: Wrapping or packaging with plastic in four bundles due to using old wrapping.

After: Wrapping with a per pallet system using a new machine can save time in the packing process.
Kaizen remarks: Customer requirements regarding product packaging must be a plastic wrap. Therefore, to maintain cleanliness and save packing time, use a wrapping machine per pallet.

The first improvement activity is to change the existing layout from 2 production area buildings to 1 production area building, especially Assembly and FI. Then for the inventory system, there was a change from the Proxpro system to the E-Kanban system, where there were many changes in the flow of materials and products that were more controlled, resulting in a difference in stock count of <1%. Meanwhile, to improve product cleaning in the FI area, we have used a cleaning tool using an airsoft gun which can speed up the process to the next stage, namely wrapping. In the warping process with a 1 pallet system, it is a customer requirement regarding product cleanliness that must always be maintained.
The companies that have implemented the Kanban system, namely that each container or pallet only has one Kanban and that Kanban must always be in its section. The quantity in the container must be the same as the amount stated on the Kanban. The Kanban post contains Kanban whose parts are being processed when production begins in downstream processes. Transport Kanban is placed at the transport Kanban post to signal the upstream process to send the part. Production Kanban is placed in the production Kanban post in the order in which parts are used. Production from upstream to downstream processes is carried out sequentially at Kanban posts (Romeira et al., 2021). All goods movements are managed by e-Kanban, and all data is entered by the operators of each section so that all production supervisors can see the movement of goods and goods balances in the e-Kanban application. The operator's work is very effective because it is assisted by the e-Kanban system to take the materials needed to complete the product. If any label is blocked it cannot be scanned and therefore cannot be moved to another stage until the label is unblocked (Martins et al., 2021).

3.6 Future State Mapping (FSM)

In this section, we will discuss the results of measuring the processing time for making four-wheeled vehicle spare parts after all improvement activities have been carried out. The results of measuring the production process time for 1 lot, namely 3,656 pcs, can be seen in Fig. 7.

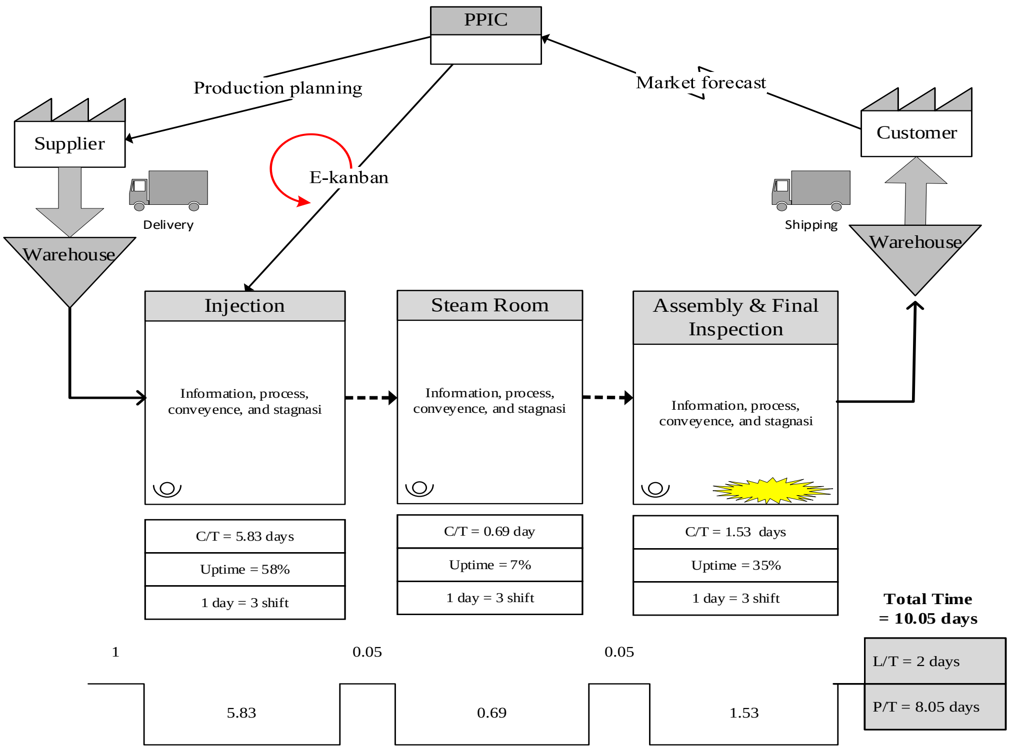

Fig. 7 Future State Mapping (FSM) diagram.

Based on Fig. 7, the results of time measurements before improvements are in the form of a CSM diagram related to the Lead Time (L/T) results of 2 days and Process Time (P/T) of 8.05 days, so the total production process time in 1 lot = 3656 pcs is 10.05 days. Calculation of L/T and P/T resulting from the start to the end process which is calculated based on all production process activities after re-layout into one production building (Tannady et al., 2019). Implementing VSM to reduce time waste by measuring C/T for each product will increase production efficiency in the manufacturing industry (Santosa & Sugarindra, 2018).

FSM measurements have been carried out using an FSM diagram, so the next activity is to break down all activities after improvement. The results of identifying waste spare parts for four-wheeled vehicles after improvements can be seen in Table 5.

Table 5 Identification of waste from making spare parts after improvement

Activity	Injection (days)	Steam Room (days)	Assembly & Final Inspection (days)
Information	4.696	0.002	1.370
Process	0.239	0.000	0.001
Conveyance	0.002	0.058	0.005
Stagnasi	0.892	0.625	0.152
Total	5.830	0.686	1.528

Based on Table 5, the production process time for making PP125-type spare parts after the re-layout combining the Assembly and FI areas is 1,370 days for the information waste category and the stagnation waste category is 0.152 days. In total, the process time for making spare parts in the Assembling and FI sections was 1,528 days, different from the results before improvements, namely 10,417 days. This greatly influences the reduction in processing time by 85.33%.

3.7 Evaluation of Research Results

In this section, we will discuss the evaluation of research results, namely by comparing the results before improvements with the results after improvements. The comparison of research results can be seen in Table 6.

Table 6 Comparison of research results

Type of Activity	Current State Map		Future State Map		Ratio Percentage (%)
	Time (days)	Percentage (%)	Time (days)	Percentage (%)	
Lead time	3.00	17.54	2.00	19.90	33.33
Process time	14.10	82.46	8.05	80.10	42.90
Total	17.10	100.00	10.05	100.00	41.22

Based on Table 6, comparing research results with both CSM and FSM results in ratio, there is a reduction in L/T time by 33.33%, P/T time by 42.90%, and in total there is a reduction in production process time for making four-wheeled vehicle spare parts by 41.22%. In this way, wasted time in the production process can be reduced and the production results for making four-wheeled vehicle spare parts for the PP125-type for six months can be seen in Fig. 8.

Please cite this article as: Pasha et al. (2024). Combination of value stream mapping (VSM) method and kanban system to reduce time waste in the production process of making parts for the four-wheel vehicle industry. *Operations Excellence: Journal of Applied Industrial Engineering*, 16(1), 76-89. doi:http://dx.doi.org/10.22441/oe.2024.v16.i1.104

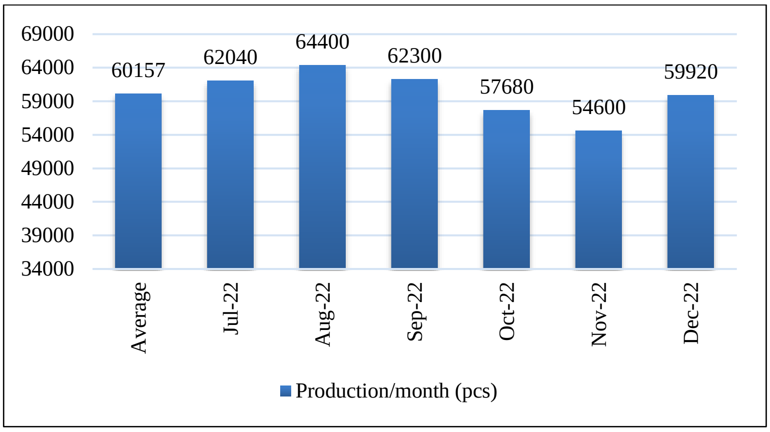

Fig. 8 Production of PP125-type plastic parts after improvement.

Based on Figure 8, the average production of PP125-type spare parts after improvements is 60,157 pcs per month. Meanwhile, the production target after the layout has changed with the new target increasing by 13,000 pcs to 67,000 pcs every month. Therefore, the results obtained from monthly production reach 90.00%. Other research has applied LM combined with RCA and the Kanban system to reduce material overstock by up to 90% so that line balancing for each part can be controlled and increase productivity (Rifqi et al., 2021).

3.8 Research Implication

In theory, the implications of this research can be used as a reference by other researchers regarding the application of Lean Manufacturing (LM) which combines the VSM method with the Kanban system in the automotive industry, especially the manufacture of plastic injection spare parts for four-wheeled vehicles. Meanwhile, the practical implications of this research can increase knowledge for industrial practitioners in terms of solutions to reduce time waste in the production process of making four-wheeled vehicle spare parts. In practice, this research has implemented the LM approach using the VSM method and running Just in Time manufacturing with the implementation of the e-kanban system. In the improvement stage, the root cause analysis method is used which consists of why-why analysis and the 5W+1H method. So it is hoped that this research can contribute to all research groups. This research includes a body of knowledge on design and engineering systems because in this research there is a re-layout process so that changes to the work system can reduce wastage of production process time and the process time becomes more effective and efficient.

4. Conclusion

This research has found that there are problems that have resulted in wasted time in the production process which consists of four factors, namely environment, people, methods, and machines. The activity problems that have been identified are waiting for information about the machine program, PPIC staff checking the product to be executed, waiting to check finished goods, waiting for information on how many products will be checked, cleaning the product and improvementing it, and wrapping the product.

This research has produced the right solution for reducing the production process time for four-wheeled vehicle spare parts, including making a closer and more sustainable re-layout of the Assembly and Final Inspection production areas, using the Kanban system both e-Kanban and manual Kanban, cleaning incoming products It becomes mandatory to go to FI, with cleaning tools using soft gun water and cleaning fluid, and a packing system that uses product wrapping with plastic per pallet. The results of measuring the production process time for 1 lot of four-wheeled vehicle spare parts decreased from 17.10 days to 10.05 days, meaning a decrease of 41.22%. This affected production results which increased from an average monthly production of 42,917 pcs to 60,157 pcs, meaning an increase of 128.65%.

In further research, researchers recommend integrating Lean Manufacturing (LM) with Green Manufacturing (GM) to reduce processing time and reduce production defects that can pollute the

ISSN-p: 2085-1431
ISSN-e: 2654-5799

environment so that cost efficiency can be achieved and the sustainability of product orders by four-wheeled vehicle manufacturing customers can be optimally increased.

References

Aisyah, S., Purba, H. H., Jaqin, C., Amelia, Z. R., & Adiyatna, H. (2021). Identification of implementation Lean, Agile, Resilient and Green (LARG) approach in indonesia automotive industry. *Journal Europeen Des Systemes Automatises*, *54*(2), 317–324. https://doi.org/10.18280/JESA.540214

Aprianto, T., Nuryono, A., Setiawan, I., Kurnia, H., & Purba, H. H. (2022). Waste Analysis in the Speaker Box Assy Process to Reduce Lead Time in the Electronic Musical Instrument Industry. *Quality Innovation Prosperity*, *26*(3), 53–65. https://doi.org/10.12776/qip.v26i3.1744

Castro, S., & Riedel, C. (2017). Assessment of the Implementation of Manufacturing Excellence in a Fiber Based Packaging Manufacturing Environment. *Procedia CIRP*, *63*, 113–118. https://doi.org/10.1016/j.procir.2017.03.104

Chiarini, A., Baccarani, C., & Mascherpa, V. (2018). Lean production, Toyota Production System and Kaizen philosophy: A conceptual analysis from the perspective of Zen Buddhism. *TQM Journal*, *30*(4), 425–438. https://doi.org/10.1108/TQM-12-2017-0178

Fam, S. F., Ismail, N., Yanto, H., Prastyo, D. D., & Lau, B. P. (2018). Lean manufacturing and overall equipment efficiency (OEE) in paper manufacturing and paper products industry. *Journal of Advanced Manufacturing Technology*, *12*(1 Special Issue 2), 461–474.

Hidayat, A. A., Kholil, M., Haekal, J., Ayuni, N. A., & Widodo, T. (2021). Lean Manufacturing Integration in Reducing the Number of Defects in the Finish Grinding Disk Brake with DMAIC and FMEA Methods in the Automotive Sub Industry Company. *International Journal Of Scientific Advances*, *2*(5), 713–718. https://doi.org/10.51542/ijscia.v2i5.7

Ikatrinasari, Z. F., Hasibuan, S., & Kosasih, K. (2018). The Implementation Lean and Green Manufacturing through Sustainable Value Stream Mapping. *IOP Conference Series: Materials Science and Engineering*, *453*(1), 1–10. https://doi.org/10.1088/1757-899X/453/1/012004

Jaqin, C., Kurnia, H., Purba, H. H., Molle, T. D., & Aisyah, S. (2023). Lean Concept to Reduce Waste of Process Time in the Plastic Injection Industry in Indonesia. *Nigerian Journal of Technological Development*, *20*(2), 73–82. https://doi.org/10.4314/njtd.v18i4.1396

Khan, R. M., & Mushtaq, A. (2022). Material Selection and Manufacturing of Halogen-Based Headlamp for Two-Wheeler Vehicle Technologies. *Iranian Journal of Chemistry and Chemical Engineering*, *41*(1), 88–108. https://doi.org/10.30492/IJCCE.2021.121678.3976

Kurnia, H., & Hardi Purba, H. (2021). A Systematic Literature Review of Lean Six Sigma in Various Industries. *Journal of Engineering and Management in Industrial System*, *9*(2), 19–30. https://doi.org/10.21776/ub.jemis.2021.009.002.3

Kurnia, H., Irwati, D., Makmudah, S., & Sofani, I. (2023). Production Control Using the Kanban System in the Manufacturing Industry in Indonesia : Systematic Literature Review International Conference International Conference. *1st Pelita International Conference*, *01*(01), 46–59. volhttps://jurnal.pelitabangsa.ac.id/index.php/pic

Kurnia, H., Jaqin, C., Purba, H. H., & Setiawan, I. (2021). Implementation of Six Sigma in the DMAIC Approach for Quality Improvement in the Knitting Socks Industry. *Tekstilvemuhendis*, *28*(124), 269–278. https://doi.org/10.7216/1300759920212812403

Kurnia, H., Setiawan, I., & Hernadewita. (2022). Integrasi Lean dan Green Manufacturing Untuk mengurangi Pemborosan Proses dan Limbah Kertas Rekrutmen Karyawan Pada Industri Manufaktur di Indonesia. *Jurnal Rekayasa Sistem Industri*, *11*(2), 145–156. https://doi.org/https://doi.org/10.26593/jrsi.v11i2.5608

Kurnia, H., Tumanggor, O. S. P., & Jaqin, C. (2021). Lean Six Sigma: Literature Review and Implementation for Textile and Textile Product (TTP) Industries. *3rd Mercu Buana Conference on Industrial Engineering-MBCIE 2021*, 1–11.

Kurniawan, W., Raharto, R., & Muryanto, M. (2022). Implementasi Kanban untuk Meminimalisir Kesalahan Penempatan pada Inventory System. *Widya Cipta: Jurnal Sekretari Dan Manajemen*, *6*(2), 162–167. https://doi.org/10.31294/widyacipta.v6i2.13658

Liker, J., & Meier, D. (2006). *The Toyota Way Fieldbook - A Practical Guide for Implementing Toyota's 4Ps* (P. Consultants (ed.); 1th ed.). McGraw-Hil.

Martins, B., Silva, C., Silva, D., MacHado, L., Brás, M., Oliveira, R., Carvalho, T., Silva, V., & Lima, R. M. (2021). Implementation of a Pull System Case Study of a Polymeric Production System for the Automotive Industry. *Management Systems in Production Engineering*, *29*(4), 253–259. https://doi.org/10.2478/mspe-2021-0031

Mirzaei, N., Nejad, M. G., & Fernandes, N. O. (2021). Combining Line Balancing Methods and Discrete Event Simulation: A Case Study from a Metalworking Company. *International Journal of Industrial Engineering and Management*, *12*(1), 14–24. https://doi.org/10.24867/IJIEM-2020-1-273

Nallusamy, S., & Adil Ahamed, M. A. (2017). Implementation of lean tools in an automotive industry for productivity enhancement - A case study. *International Journal of Engineering Research in Africa*, *29*(1), 175–185. https://doi.org/10.4028/JERA.29.175

Nuryono, A., Kurnia, H., & Zulkarnaen, I. (2024). Spare parts warehouse re-layout design with kaizen 5S implementation to reduce wasted time searching for machine parts. *Operations Excellence: Journal of Applied Industrial Engineering*, *15*(3), 293–305. https://doi.org/10.22441/oe.2023.v15.i3.095

Purba, H. H., Mukhlisin, & Aisyah, S. (2018). Productivity improvement picking order by appropriate method, value stream mapping analysis, and storage design: A case study in automotive part center. *Management and Production Engineering Review*, *9*(1), 71–81. https://doi.org/10.24425/119402

Rifqi, H., Zamma, A., Souda, S. B., & Hansali, M. (2021). Lean manufacturing implementation through DMAIC approach: A case study in the automotive industry. *Quality Innovation Prosperity*, *25*(2), 54–77. https://doi.org/10.12776/qip.v25i2.1576

Romeira, B., Cunha, F., & Moura, A. (2021). Development and Application of an e-Kanban System in the Automotive Industry. *International Conference on Industrial Engineering and Operations Management*, 613–624. http://ieomsociety.org/proceedings/2021monterrey/101.pdf

Rose, A. N. M., Mohamed, N. M. Z. N., Ab Rashid, M. F. F., Noor, H. M., & Mohd, A. (2020). Improving productivity through value stream mapping (VSM): A case study at electrical & electronic company. *Journal of Physics: Conference Series*, *1532*(1). https://doi.org/10.1088/1742-6596/1532/1/012005

Saing, B., Kustiyah, E., Agustin, D. Y., Amalia, R. Y., & Kurnia, H. (2023). Main hazard control and hazardous material handling in environment testing laboratory. *Operations Excellence: Journal of Applied Industrial Engineering*, *12*(3), 176–185. https://doi.org/10.22441/oe.2023.v15.i2.083

Salvador, R., Piekarski, C. M., & Francisco, A. C. de. (2017). Approach of the Two-way Influence Between Lean and Green Manufacturing and its Connection to Related Organisational Areas. *International Journal of Production Management and Engineering*, *5*(2), 73. https://doi.org/10.4995/ijpme.2017.7013

Santosa, W. A., & Sugarindra, M. (2018). Implementation of lean manufacturing to reduce waste in the production line with value stream mapping approach and Kaizen in division sanding upright piano, a case study in PT. X. *MATEC Web of Conferences*, *154*, 8–11. https://doi.org/10.1051/matecconf/201815401095

Setiawan, B., Setiawan, I., Kurnia, H., Wahid, M., & Purba, H. H. (2022). Implementasi Metode Value Stream Mapping Pada Industri: Tinjauan Literatur Sistematis. *Inaque : Journal of Industrial and Quality Engineering*, *10*(2), 103–116. https://doi.org/10.34010/iqe.v10i2.5989

Setiawan, S., Setiawan, I., Jaqin, C., Prabowo, H. A., & Purba, H. H. (2021). Integration of Waste Assessment Model and Lean Automation to Improve Process Cycle Efficiency in the Automotive Industry. *Quality Innovation Prosperity*, *25*(3), 48–64. https://doi.org/10.12776/qip.v25i3.1613

Sjarifudin, D., & Kurnia, H. (2022). The PDCA Approach with Seven Quality Tools for Quality Improvement Men ' s Formal Jackets in Indonesia Garment Industry. *Jurnal Sistem Teknik Industri (JSTI)*, *24*(2), 159–176. https://doi.org/10.32734/jsti.v24i2.7711

Sjarifudin, D., Kurnia, H., Purba, H. H., & Jaqin, C. (2022). Implementation of the Six Sigma approach for increasing the quality of formal men's jackets in the garment industry. *Jurnal Sistem Dan Manajemen Industri*, *6*(1), 33–44. https://doi.org/10.30656/jsmi.v6i1.4359

Tannady, H., Gunawan, E., Nurprihatin, F., & Wilujeng, F. R. (2019). Process improvement to reduce waste in the biggest instant noodle manufacturing company in South East Asia. *Journal of Applied Engineering Science*, *17*(2), 203–212. https://doi.org/10.5937/jaes17-18951

W Creswell, J. (2014). Research-Design_Qualitative-Quantitative-and-Mixed-Methods-Approaches Forth Edition. In V. Knight (Ed.), *Sage Publication* (Fourth Edi). Sage Publication Ltd.

Wiyatno, T. N., & Kurnia, H. (2022). Increasing Overall Equipment Effectiveness in the Computer Numerical Control Lathe Machines Using the Total Productive Maintenance Approach. *Jurnal Optimasi Sistem Industri*, *15*(2), 284–292. https://doi.org/10.31315/opsi.v15i1.7284

Zulkarnaen, I., Kurnia, H., Saing, B., & Nuryono, A. (2023). Reduced painting defects in the 4-wheeled vehicle industry on product type H-1 using the lean six sigma-DMAIC approach. *Jurnal Sistem Dan Manajemen Industri (JSMI)*, *7*(2), 179–192. https://doi.org/10.30656/jsmi.v7i2.7512

Please cite this article as: Pasha et al. (2024). Combination of value stream mapping (VSM) method and kanban system to reduce time waste in the production process of making parts for the four-wheel vehicle industry. *Operations Excellence: Journal of Applied Industrial Engineering*, 16(1), 76-89. doi:http://dx.doi.org/10.22441/oe.2024.v16.i1.104