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

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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, completion 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

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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%.

Keywords
Increase Production
Kaizen
Re-layout
Reduce Process Time
Root Cause Analysis

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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).

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).
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.](image)

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

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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.

![Material Check Diagram]

**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.

![Production Graph]

**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

<table>
<thead>
<tr>
<th>Activity</th>
<th>Injection (days)</th>
<th>Steam Room (days)</th>
<th>Assembly (days)</th>
<th>Final Inspection (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Information</td>
<td>0.865</td>
<td>0.857</td>
<td>5.190</td>
<td></td>
</tr>
<tr>
<td>Process</td>
<td>0.239</td>
<td>0.000</td>
<td>0.002</td>
<td></td>
</tr>
<tr>
<td>Conveyance</td>
<td>0.008</td>
<td>0.054</td>
<td>0.013</td>
<td>0.038</td>
</tr>
<tr>
<td>Stagnasi</td>
<td>2.492</td>
<td>0.040</td>
<td>1.382</td>
<td>2.932</td>
</tr>
<tr>
<td>Total</td>
<td>3.605</td>
<td>0.094</td>
<td>2.252</td>
<td>8.163</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Process</th>
<th>Activity</th>
<th>Activity identification</th>
<th>Time (days)</th>
<th>Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Waiting for information on the machine program</td>
<td>0.300</td>
<td>VA</td>
</tr>
<tr>
<td></td>
<td>Assembly</td>
<td>PPIC staff checks the product that will run</td>
<td>0.382</td>
<td>NVA</td>
</tr>
<tr>
<td></td>
<td>Setting Machine</td>
<td>Install the product on Jig, run the the process</td>
<td>0.557</td>
<td>NNVA</td>
</tr>
<tr>
<td></td>
<td>Setting Product</td>
<td>Waiting to check the finished goods</td>
<td>1.000</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Visual Check</td>
<td>Waiting for information on how many products to check</td>
<td>4.000</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Wrapping</td>
<td>Cleaning the product and improvement</td>
<td>2.932</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Wrapping the product</td>
<td>1.190</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td></td>
<td>10.361</td>
<td>0.382</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>5.190</td>
<td>0.557</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2.252</td>
<td>1.300</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>8.504</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>No</th>
<th>Issue</th>
<th>Why 1</th>
<th>Why 2</th>
<th>Why 3</th>
<th>Why 4</th>
<th>Why 5</th>
</tr>
</thead>
</table>
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 improved 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

<table>
<thead>
<tr>
<th>No</th>
<th>Issue</th>
<th>Why 1</th>
<th>Why 2</th>
<th>Why 3</th>
<th>Why 4</th>
<th>Why 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>Waiting to check the finished goods</td>
<td>manually on the Proxpro system</td>
<td>old system</td>
<td>inventory system</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>4</td>
<td>Waiting for information on how many products to check</td>
<td>Finish goods require a long inspection because it is 1 lot</td>
<td>Manual inspection</td>
<td>There is no comprehensive inspection system yet</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>5</td>
<td>Cleaning the product and improvement</td>
<td>Number of products checked manually</td>
<td>Waiting for manual confirmation from superiors</td>
<td>No system can quickly provide decisions</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>6</td>
<td>Wrapping the product</td>
<td>Product inspection and improvement process</td>
<td>Before sending it to customers, make sure the product status is OK</td>
<td>As a quality assurance requirement</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Table 4 5W+1H improvement plan

<table>
<thead>
<tr>
<th>Factor</th>
<th>What</th>
<th>Why</th>
<th>Where</th>
<th>When</th>
<th>Who</th>
<th>How</th>
</tr>
</thead>
<tbody>
<tr>
<td>Environment</td>
<td>Waiting for information on the machine program</td>
<td>Buildings 1 and 2 are far apart</td>
<td>Assembly area</td>
<td>Jan-22</td>
<td>Vendors and Technician s</td>
<td>Re-layout and transfer of Assembly machines to Building 1</td>
</tr>
<tr>
<td>Man</td>
<td>PPIC staff checks the product that will run</td>
<td>There has been no change to the inventory system</td>
<td>Production area</td>
<td>Feb-22</td>
<td>PPIC</td>
<td>Change of Proxpro system to Kanban system</td>
</tr>
<tr>
<td>Man</td>
<td>Waiting to check the finished goods</td>
<td>There is no comprehensive inspection system yet</td>
<td>Final Inspection area</td>
<td>Mar-22</td>
<td>QC</td>
<td>Use of an inspection system with the Kanban system</td>
</tr>
</tbody>
</table>
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.](image-url)
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

<table>
<thead>
<tr>
<th>Activity</th>
<th>Injection (days)</th>
<th>Steam Room (days)</th>
<th>Assembly &amp; Final Inspection (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Information</td>
<td>4.696</td>
<td>0.002</td>
<td>1.370</td>
</tr>
<tr>
<td>Process</td>
<td>0.239</td>
<td>0.000</td>
<td>0.001</td>
</tr>
<tr>
<td>Conveyance</td>
<td>0.002</td>
<td>0.058</td>
<td>0.005</td>
</tr>
<tr>
<td>Stagnasi</td>
<td>0.892</td>
<td>0.625</td>
<td>0.152</td>
</tr>
<tr>
<td>Total</td>
<td>5.830</td>
<td>0.686</td>
<td>1.528</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Type of Activity</th>
<th>Current State Map</th>
<th>Future State Map</th>
<th>Ratio Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Time (days)</td>
<td>Percentage (%)</td>
<td>Time (days)</td>
</tr>
<tr>
<td>Lead time</td>
<td>3.00</td>
<td>17.54</td>
<td>2.00</td>
</tr>
<tr>
<td>Process time</td>
<td>14.10</td>
<td>82.46</td>
<td>8.05</td>
</tr>
<tr>
<td>Total</td>
<td>17.10</td>
<td>100.00</td>
<td>10.05</td>
</tr>
</tbody>
</table>

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.
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 improving 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...
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


