Application of lean manufacturing in reducing cycle time in the cylinder head component at PT TM

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ABSTRACT

The manufacturing industry continues to grow with intense competition, so companies need to improve efficiency and reduce waste in the production process. Lean Manufacturing with Kaizen approach is one of the effective methods to optimize workflow and reduce waste. PT TM faces problems in the production process, especially in the post 2 packing component cylinder head, where there are cycle time fluctuations that have an impact on production efficiency. To overcome these problems, the Lean Manufacturing method with Kaizen approach is applied to reduce waste and improve production efficiency. This study aims to analyze the effect of Kaizen implementation in reducing cycle time and identifying waste that occurs in the production process. The results showed that the implementation of Kaizen succeeded in reducing cycle time from 97 seconds to 80 seconds, with a takt time of 105 seconds. In addition, two types of waste were found, namely waiting for 25 seconds and motion for 6 seconds, which have been minimized through changes in layout and work procedures. These findings demonstrate the potential of the Kaizen method not only for improving efficiency at PT TM, but also for broader application in similar production settings aiming to enhance operational performance and reduce waste sustainably.

1. Introduction

The manufacturing industry is a processing industry, which is a business that processes or converts raw materials into finished goods or semi-finished goods that have added value, which is done mechanically with machines, or without using machines (manual) (Permana & Pujani, 2020). Industrialization is a process of interaction between technological development, specialization innovation, in production and trade between countries which ultimately in line with the increase in per capita income encourages changes in economic structure. This processing is done through various stages of production, either using machines (automatic or semi-automatic) or manually. The results of the manufacturing industry can be in the form of products ready for direct consumption by the public (such as food, clothing, and electronics) or components used in other production processes (such as machine parts or building materials) (Kumar et al., 2022). Industrialization is often also interpreted as a process of economic modernization that includes all sectors of the economy that include all existing economies that are directly or indirectly related to the manufacturing industry. At any time, competition in the industrial world cannot be avoided by a company. Therefore, every company strives to increase the productivity of its company in all aspects. The company's efforts to increase productivity by making continuous improvements, with continuous improvement a company can minimize waste. Waste is any production activity that does not provide added value in the process of transforming inputs into outputs

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throughout the process of making, producing and delivering products in the form of goods or services (Fatma et al., 2022).

Lean Manufacturing is an approach used to minimize waste with the goal of increasing value for customers, reducing the amount of resources consumed and cycle time through the elimination of waste. Lean Manufacturing is a production methodology that focuses on reducing (young) waste without reducing productivity. This methodology aims to improve efficiency by eliminating non-value-added activities in the production process (Pratama & Al Faritsy, 2024). The implementation of Lean Manufacturing in a company itself is currently widely used, especially in large companies. From a business point of view, the Lean Manufacturing approach is a good method to reduce waste problems that exist in the company. In Lean Manufacturing there are tools or methods that can be used, one of the tools used in this research is the Kaizen method. Kaizen is an improvement made by eliminating waste, eliminating excess workload, and always improving the quality of products produced. The main goal of Kaizen is to eliminate waste that does not add value to the product or service. Waste needs to be eliminated because it causes costs that cause reduced profits. The application of Kaizen can be done at the beginning of the production process, during the production process, until the final process of the goods stored in the warehouse and ready to be sent to the customer (Khunaifi et al., 2022). So that what is produced has a high selling value with good quality. In addition, the application of Kaizen will increase productivity more efficiently, effectively and reduce production costs by reducing the number of damaged or Not Good (NG) goods. Kaizen is a Japanese management philosophy that means continuous improvement (Deming, 2018).

This concept emphasizes the importance of making small changes consistently to improve efficiency, productivity, and quality in a work process. Kaizen involves all elements in the organization, from top management to workers on the production line, to jointly identify problems, find solutions, and implement improvements (Aisyah, 2020). The main focus of Kaizen is to eliminate waste in all forms, such as time, energy, and resources, and create new, more effective work standards after improvements are made. With this approach, Kaizen not only improves operational performance, but also builds a work culture that is collaborative and adaptive to change. Kaizen implementation helps create a work culture that is adaptive to change and encourages continuous innovation (Johan & Soediantono, 2022). However, intense competition in the industrial world requires companies to continuously improve overall performance. One of the strategies used to achieve production efficiency and effectiveness is through the application of Kaizen. Kaizen, which comes from Japanese, means “continuous improvement”. This concept emphasizes the importance of making continuous small improvements in work processes, which can cumulatively result in large improvements in productivity, quality, and cost savings. Kaizen is not only a technical method but also reflects a work culture that promotes collaboration and involvement of all parties in the organization-from management to production line workers. Through Kaizen, companies are invited to actively identify and eliminate waste, which is any activity in the production process that does not provide added value, such as waiting time, excess movement, excess inventory, and unnecessary production. One of the tools often used in Kaizen is the PDCA cycle (Plan-Do-Check-Act), which serves as a framework for implementing and evaluating improvements systematically (Larasati & Laksono, 2022). The implementation of Kaizen is proven to not only improve operational efficiency, but also create a better work environment, improve employee morale, and encourage continuous innovation. Studies by Setiawan and Lestari (2021) show that the application of Kaizen in the manufacturing industry has succeeded in reducing production process time and identifying two main types of waste, namely waiting and motion, which can then be minimized through rearranging work layouts and work procedures (Setiawan et al., 2022).

Several previous studies have examined the application of Lean Manufacturing across various industries. Irawan & Putra (2021) reported that, based on the Waste Assessment Model (WAM), the most critical wastes were defects (18.02%), transportation (16.14%), and unnecessary motion (15.06%). Pattiapon et al. (2020) also analyzed lean implementation and identified the three highest waste categories as waiting (17.1%), inappropriate processing (16.5%), and overproduction (15.9%). To reduce waiting waste, the authors recommended operator training and additional manpower.

Anjani & Pratiwi (2022) applied Lean Manufacturing using Value Stream Mapping (VSM) and found that the dominant wastes included overproduction, waiting, and inventory. Similarly, Komariah (2022)identified inventory as the highest waste category, with a magnitude of 19.6% or 14,928.8 seconds. Through fishbone analysis, several improvement proposals were generated, including

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assigning operators to packing, providing material-handling operators, supplying mover tools, and eliminating non–value-added activities.

Sembiring (2018) also examined lean implementation using VSM and recommended improvements such as the use of forklifts, additional operators, and additional machines. The evaluation of these recommendations resulted in a reduction of production lead time by 8,610.62 seconds and an increase in Process Cycle Efficiency (PCE) by 21.08%. A comparison of the findings from previous studies is presented in the following Table 1.

Table 1 Comparison of previous research

Study	Focus	Identified Wastes	Improvement Method
This Study (PT TM)	Packing Post 2	Waiting (25s), Motion (6s)	Kaizen (layout, work procedure)
Irawan & Putra (2021)	Plastic pallets	Defects, Motion, Transport	WAM
Pattiapon et al. (2020)	Production floor	Waiting, Processing, Overproduction	Training, Manpower
Anjani & Pratiwi (2022)	Brick production	Overproduction, Waiting, Inventory	VSM, WAM
Komariah (2022)	Pan production	Inventory	VSM, Fishbone
Sembiring (2018)	Assembly line	Not specified	Equipment & staffing

In contrast to previous studies that generally use the Value Stream Mapping (VSM), Waste Assessment Model (WAM), or improvement through additional manpower and equipment investment, this study uses changes in work procedures and layout, without requiring large investments. In addition, the study also highlighted two main types of waste, namely waiting and motion, which were successfully minimized through a participatory approach and continuous improvement. Thus, this research provides practical and applicable contributions in the context of simple yet effective production process efficiency, especially for automotive manufacturing companies that want to optimize specific production lines in a focused and measurable manner.

PT TM is one of the automotive manufacturing industries that operates to produce TR Engine (Vehicle Engine) and Ethanol Engine. This research makes the packing line component cylinder head post 2 as the place to be observed. The production process in this company is carried out continuously, but in actuality there are often fluctuations in cycle time in the production process, especially in post 2 packom cylinder head. Based on the data obtained in 2023, the cycle time at post 2 packom cylinder head is 103 seconds with a takt time of 105 seconds. Therefore, further identification is needed to reduce fluctuations in cycle time and Kaizen to the problems that occur so that cycle time can be smaller than before at PT TM. The concept of lean manufacturing is used to reduce waste in the company's production process. In order to reduce waste at PT TM, it can use the application of Lean Manufacturing using the Kaizen method. The purpose of this research is to find out how the application of Kaizen in improving efficiency and product quality.

2. Methods

Object of Research

The object of this research is the packing process of cylinder head components at post 2 in TM. This process experiences cycle time fluctuations, which have the potential to hinder production efficiency and cause waste. Therefore, this research focuses on the application of the Kaizen method in Lean Manufacturing to identify the causes of waste and optimize cycle time so that the production process runs more effectively and efficiently.

Data Collection Technique

The data collection techniques used in this research include the following techniques:

a. Observation

This observation method aims to understand how the workflow or process occurs in a series of jobs in the Visual Inspection Team of the Quality Control Department.

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b. Interview

Interviews in this study were conducted directly to the production department logistics division. The production department itself is responsible for the continuity of the production process from the preparation of raw materials to the storage of the final product and is responsible for production results, product quality, and time and material efficiency according to company targets. Data obtained from several data collection methods carried out, including data such as the cycle time of the work performed, as well as data about the operator to be studied.

Kaizen Implementation Framework

The implementation of Kaizen follows a structured continuous improvement cycle, adapted from the PDCA (Plan-Do-Check-Act) model. The steps include:

a. Identification of problems through direct observation and time measurement.
b. Root cause analysis using a Fishbone Diagram to map contributing factors.
c. Data analysis and baseline assessment via cycle time and takt time comparison.
d. Design of improvements, including layout and procedural changes.
e. Implementation of changes with operator involvement.
f. Post-implementation measurement to evaluate impact and validate improvement.

The tools used in this process include time study sheets, Fishbone diagrams, and Kaizen event documentation to ensure systematic implementation and traceability.

Analytical Tools and Quantification

While qualitative insights provided context, the study's rigor is strengthened through quantitative analysis of:

a. Cycle time reduction (from 97s to 80s)
b. Takt time stability (remains at 105s)
c. Waste quantifications are waiting time = 25 seconds and motion waste = 6 seconds

Research Flow

The research is focused on applying the Lean Manufacturing concept with the Kaizen method to reduce the fluctuating cycle time and identify the types of waste that occur during the production process. The limitation of this research is that it is only limited to Post 2 of the cylinder head component packing process and does not cover the entire production line. The data used is limited to time data such as cycle time and takt time, and the improvement method used only focuses on Kaizen. The following is the research flow in Fig. 1.

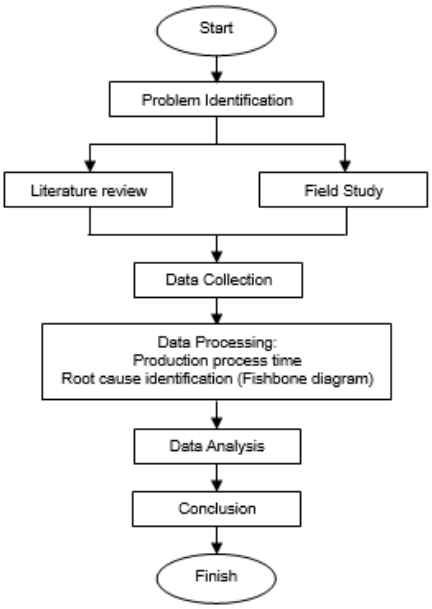

Fig. 1 Research flow.

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3. Results and Discussion

The limitation of this research is that it is only limited to Post 2 of the cylinder head component packing process and does not cover the entire production line. The data used is limited to time data such as cycle time and takt time, and the improvement method used only focuses on Kaizen. In this study, preliminary data is needed before being processed using the Kaizen method, below are the data needed in processing the method. The data needed such as last year's Standard work combination data, are as follows:

Table 2 Combination work standard data year 2023

No.	*Sequence of Work*	Time (Second)
1	*Tilt the table 45^o. Check Upper Face with Lamp*	20
2	*Press Button Lifter Up, Home Position Table 45^o*	2
3	*Visual Check Cam Hole Ex, Turn Table 180^o, Visual check Cam Hole In*	15
4	*Cleaning Spark plug hole, Turn Table clockwise 90^o*	8
5	*Visual Check RR Face + cleaning*	15
6	*Turn Tabel Counterclockwise 90^o*	2
7	*Visual Check in Mani Face + Cleaning*	18
8	*Turn table clockwise 90^o*	2
9	*Visual Check Front Face + cleaning*	15
10	*Turn Table Clockwise 270^o (Home Position)*	2
11	*Press Button Lifter Down*	2
12	*Push Cylinder Head to Roll Over*	2
Total		103

Based on the Table 2, the total cycle time that occurs is 103 seconds with a takt time of 105 seconds. Then observation data is also needed to see the actual time with last year's data, so that later improvements or Kaizen can be made. The following is the data from the observation for comparison:

Table 3 Work standard data before Kaizen

No.	*Sequence of Work*	Time (Second)
1	*Tilt the table 45^o. Clean top face, check with lamp* (2)	40
2	*Press lifter up button, Home Position Table 45^o*	1
3	*Cleaning & part plug hole*	3
4	*Turn table* 90^o *clockwise*, *VC of camera hole Ex*, *Turn Table* 180^o *clockwise*, *Turn table* 90^o *clockwise*, *VC of cam hole in*	10
5	*Turn Table* 90^o *clockwise*, *VC of R & face cleaning*, *put dot*	12
6	*Turn Table* 90^o *clockwise, in many facecleaning, VC, put dot*	14
7	*Turn Table* 90^o *clockwise*	1
8	*VC of F & face, cleaning*	9
9	*Turn Table* 270^o (*home position*) *clockwise*	4
10	*Press lifter down button*	2
11	*Push Cylinder Head to Roll Over*	1
Total		97

Based on the Table 3, the actual total cycle time is 97 seconds with a takt time of 105 seconds. It turns out that the actual data is better than last year's data, but Kaizen is still needed so that the production process can be more effective and efficient. After data collection and direct observation in the production process area, the data is group and data processing is carried out as follows:

a. Kaizen Implementation Steps

There are steps to implement Kaizen that are effective and can maintain conformity itself to existing standards. The steps taken by the company to implement Kaizen include the following.

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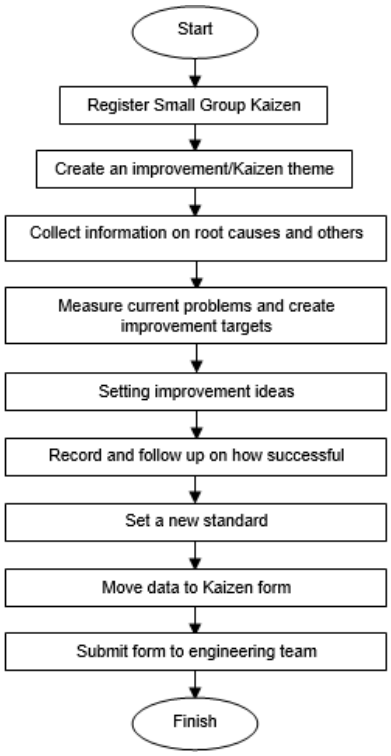

Fig. 2 Steps to implement Kaizen.

b. Waste Identification on the Cylinder Head Post 2 Component Packing Production Line
From the observations made, several types of waste that occur in the post 2 cylinder head component packing production line are identified as follows:

Waiting
Waiting time is caused by imbalances in the production flow, often due to technical problems in the machine or lack of coordination between production sections. This waiting category waste is an inefficient use of time or lost time caused by several factors (loss time). In this observation, there is a waiting time of 25 seconds.

Motion
In the existing production process, waste motion usually arises due to the movements of operators that do not add value to the product. From the identification results in the ongoing production process, there are non-value added activities with a total of 6 seconds.

c. Effect of Kaizen Implementation in Improving Time Efficiency
Kaizen, which means continuous improvement, is a key concept in Lean Manufacturing that focuses on reducing waste and increasing efficiency. The application of Kaizen at PT TM, especially in the cylinder head post 2 component packing line, aims to identify and eliminate activities that do not provide added value. In its implementation, Kaizen involves all employees to participate in the improvement process. They are invited to provide input and innovative ideas that can improve production efficiency. The effect of Kaizen can be seen in the Table 4 and Fig. 3.

Table 4 Work standard data after Kaizen

No.	*Sequence of Work*	Time (Second)
1	*Tilt the table 45^o. Clean top face, check with lamp* (1)	35
2	*Press lifter up button, Home Position Table 45^o*	1
3	*Cleaning & part plug hole*	3
4	*VC of camera hole Ex*, *Turn Table* 180^o, *VC of cam hole in*	10

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No.	*Sequence of Work*	Time (Second)
5	*Turn Table 90° clockwise, VC of front face*	6
6	*Turn Table 90° clockwise, VC of Mani face*	11
7	*Turn Table 90° clockwise, VC of RR face*	10
8	*Turn Table 90° clockwise, VC of home position*	1
9	*Press lifter down button*	2
10	*Push CH to rollover*	1
Total		80

Based on the Fig. 3 and Table 4, the combination work standard after Kaizen above shows that the cycle time is at 80 seconds with a takt time of 105 seconds. The decrease in cycle time by 17 seconds shows a significant increase in efficiency in the packaging process. This means that the time required to complete one unit of product has been reduced, enabling a faster and more efficient packaging process on the cylinder head post 2 component packing production line, as well as potential waste reduction and overall productivity improvement. Here is one of the Kaizen that has been done:

Condition before Kaizen

Condition after Kaizen

Fig. 3 The state before and after Kaizen.

d. Waste that Occurs in the Cylinder Head Post 2 Component Packing Production Line

Based on observations, there is a waiting time of 25 seconds and 6 seconds of non-value add activities. Therefore, it is important to immediately identify and eliminate these wastes through machine improvements, improved coordination, timely material provision, good workplace layout design, and adequate operator training.

Fishbone diagram are made to determine the cause and effect of existing problems, therefore a fishbone diagram is made to identify the causes of cycle time fluctuations at PT TM as in Fig. 4.

Fig. 4 Fishbone diagram.

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e. Proposed Improvements

Based on the analysis and discussion that has been carried out, the proposed improvements that can be made are in the work sequence or operation number 1 B changing the lamp from 2 to 1 but extending the lamp to reach the part that you want to do a visual check. It is only necessary to rotate the table 90o clockwise to visually check the front face, mani face, RR face, and home position in operations 1, 5, 6, 7, and 8. That way it will reduce the cycle time by 17 seconds from 97 seconds of actual time when observing to 80 seconds of operation time after applying Kaizen. In addition, involving all employees in the improvement process by encouraging active participation and innovative ideas from them to improve production efficiency. In addition, it is also necessary to conduct regular evaluation and monitoring of the implementation of the improvement plan that has been designed to ensure that the changes implemented can provide the expected results.

4. Conclusion

From the analysis conducted at PT TM, it can be concluded that the application of the Kaizen method has proven to be influential in improving the efficiency of production time and identifying and overcoming waste that occurs in the production process. Which can be seen from the decrease in cycle time from 97 seconds to 80 seconds. It is also known that the types of waste that occur are waste waiting for 25 seconds and waste motion for 6 seconds which are resolved. There are 2 wastes that occur in the post 2 cylinders head component packing production line, namely wate waiting for 25 seconds and waste motion for 6 seconds. Proposed improvements that can be given to the production line packing component cylinder head post 2 on work sequence or operation number 1 change the 2 lights to 1 but extend the lamp to reach the part you want to do a visual check. Only need to rotate the table 90o clockwise to visually check the front face, mani face, RR face, and home position in operations 1, 5, 6, 7, and 8.

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