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Research Article

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Lean Manufacturing Design to Reduce Waste in Gear Production Process Using VSM and Kaizen Method Approaches (Case Study: Gear Primary Driven K56 Product)

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Abstract PT. XYZ is a manufacturing company which is engaged in automotive production of Gear products as its main product. One product is the Primary Driven Gear K56. In the production process in the company, there is still some waste found. To reduce the waste that occurs, lean manufacturing design using the Value Stream Mapping (VSM) method is used to map the production flow and information flow to a product at the production level, and Kaizen to provide proposed corrective actions on the production line. The purpose of this study is to identify and reduce waste and make improvements to the stages of waste that occur. The results showed that two wastes occurred, namely product defects due to the process and the length of time for distribution. It is known that the kirikokami defect is the highest defect which is 1.03% in 2019, with fishbone analysis and 5W + 1H, it is proposed to improve by making a standardization / SOP. In VSM, the actual distribution cycle waste time is 10563.40 minutes; after analyzing the proposed improvement, the shorter distribution cycle time is 1593.23.

Keywords Lean Manufacturing, Value Stream Mapping, Kaizen

Introduction

PT. XYZ is a manufacturing company which is engaged in automotive production of Gear products as its main product. The other forms of products produced by this company, such as camshafts, starting gears, primary gears, outer clutch, idle shafts, clutch pistons, and timing sprocket.

Figure 1: Gear Primary Driven K56

The products produced by PT. XYZ is exported. It is known that Gear products have the highest defect ratio compared to other defect ratios. To achieve the company's target in meeting Gear market share, the company must always improve production quality in accordance with the company's target by emphasizing zero defects. In figure 1, data on the number of requests for K56 Gear Primary Driven products during the period of June - November 2019.

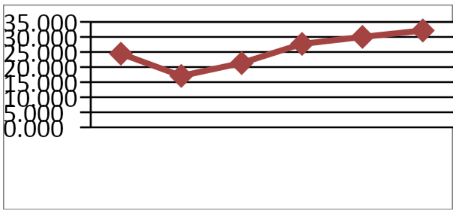

Figure 2: Demand Grap from June to November

In achieving this zero-defect target, the company has difficulty implementing/realizing the target. Based on Table 1 explains that from June to November 2019, it is known that the total defect produced overall is 6.55% of total production.

Table 1: Number of Product Defects at PT.XYZ

Month	Total Defect Product Gear Primary Driven K56	Number of Product Requests	% Defect
June	250	24,420	1.02
July	183	17,064	1.07
August	230	21,336	1.08
September	281	27,702	1.01
October	450	30,000	1.50
November	280	32,160	0.87

This research at PT. XYZ will be conducted on Gear Primary Driven K56 type products because this product is the main product of the Non-Transmission Line, which has a significant demand but has a high amount of defects compared to other products. The demand for this K56 Primary Driven Gear product is an average of around 25,447 pcs per month. Therefore the existence of waste defects in this company needs to be eliminated.

Unnecessary inventory is also found in the Non-Transmission Line production line, namely the queue of material that will enter the lathe process due to the lathe machine is still working on the previous material, this will lead to work in process (WIP) which can reduce company productivity. Material that experiences this queue can take more than 60 minutes to experience the process on the next machine. In this process, the material has a buildup or queue, so some materials must be silenced first and done later.

The waste in PT.XYZ, especially in the Non Transmission production line, will undoubtedly cause losses to the company. The form of losses that can be borne by the company, such as losses in terms of costs, less than the maximum number of products produced, and affect the efficiency of time used, so that the existence of this waste needs to be identified and analyzed so that suggestions can be given improvements.

To reduce waste that occurs, companies can use the concept of Lean. Lean is an approach in identifying and eliminating waste or non-value added activities through continuous improvement by flowing products and information using a pull system from customers to pursue excellence. In the Lean concept, one method that can be used to reduce or eliminate waste is the Value Stream Mapping method reported by Adrianto & Kholil.

Lean Manufacturing is a concept initially developed by Toyota, then known as Just - In - Time Manufacturing. The concept of Lean Manufacturing aims to change an organization in the company to be more efficient and competitive. The application of the Lean Manufacturing concept is to reduce lead time and increase output by eliminating waste that occurs in a company. From the problems above, this study uses value stream mapping (VSM), which is one of the tools from Lean Manufacturing to solve existing problems. From the use of VSM, it is expected to optimize performance and minimize or eliminate waste on the production floor. Then, this study also applies the Kaizen method to improve the quality level of a product.

With the implementation of the Lean Manufacturing concept as an effort to reduce waste that occurs in processes that take place in the Non-Transmission Line of PT. XYZ is expected to be able to have a positive impact on this company, namely by increasing the value of the efficiency of the processes that take place in that section.

Materials and Methods

The research method is a stage of research that must be determined first before carrying out the problem-solving process so that research can be done with more directed and controlled and make it easier to analyze existing problems that are identifying and reducing waste that inhibits productivity and provides suggestions for improvement with the Kaizen method approach to the stages minimize waste (waste) that occurs in the Gear Primary Driven K56 product by applying the Value Stream Mapping method.

Based on the above definition, the method used in this research is descriptive and quantitative; this study describes the conditions in the production line of K56's Primary Driven Gear manufacturing and can study the problems that occur in the production process until storage. Data processing is performed using the Value Stream Mapping method with the Kaizen approach. The steps are as follows:

1. Understanding the work system and work environment in the company, while making direct observations of the area of K56 Gear Primary Driven manufacturing, it is supported by a literature study to establish the theoretical basis of Value Stream Mapping and Kaizen.
2. Begin to identify problems that often result in defects to the length of time waiting for distribution to the next process.
3. Determine the final results or targets to be achieved in this study and consider approximately whether it is possible to make improvements in one particular process.
4. Enter data processing, determine which parts can be improved, then validate existing data. If the data is still not valid, repeat the data collection process.
5. After the data has been processed, development or improvement of the existing process is carried out, and it is hoped that at this stage, the problem of defects and the length of time for distribution can be reduced (Kaizen).
6. Standardize the development of processes that have been carried out.
7. Conclude, and give advice.

Results & Discussion

Defect Analysis of Primary Driven Gear Product K56

In the measurement activity on the Primary Driven Gear Demand & Defect Gear Data, it can be seen that the highest average defect percentage occurred in 2019 of 1.03%. In the one year in 2019, there was a significant increase in the number of defects in June - November, especially in the type of kirikokami defects. For this reason, researchers decided to conduct in-depth research in that month.

Processing results obtained one priority, the main type of defect, Primary Gear Driven K56 products. The main failure type of the Gear Primary Driven K56 product is Kirikokami. The cause of the defect is known by analyzing the formation of the Fishbone Diagram. It is known that the cause of kirikokami defects occurs due to several factors, namely, Man where the operator does not understand the area where there is no risk, a machine where there is no unique cleaning tool on the pitch gauge, and a method where there is no standardization for the spraying process.

Work Time Measurement Analysis

In the activity of measuring work time (time study), five activities have been carried out, including:

1. Measurement of cycle time
2. Test data uniformity
3. Test the adequacy of the data
4. Normal time calculation
5. Determination of the standard time

The cycle time (cycle time) that has been obtained is the time required by Lathe, Hobbing, Chamfering, and Fine Boring operators to complete every activity they do. In this study, the authors only focus on the Non-Transmission Line Production Line of Primary Driven Gear K56 products, because this product is the main product of the Non-Transmission Line, which has great demand but has a high amount of defects compared to other products.

Calculation of data uniformity test for all samples owned, the results obtained that all cycle times that have been measured have met the requirements, which is within the control range of the data uniformity test. That way, the results of time measurements that have been made are said to be uniform and can be continued as research data.

In addition to the data uniformity test, a data sufficiency test is also carried out to determine whether the data obtained is sufficient to be used as research data. From the results of the calculation of the data adequacy test conducted on the data held, it shows that the number of measurements needed for each activity is less than the number of measurements that have been made, or can be denoted by N '<N, so it can be seen that the sample taken can represent all population.

Then after the data adequacy test is then performed, the standard time calculation to find out the amount of time needed by the operator to complete the making of the Primary Driven K56 Gear product per lot at each stage of the process carried out.

After the data from the measurement of the time taken is said to be uniform and sufficient, the final step is to determine the standard time (Wb) or standard time of each activity carried out by the operator. In determining the standard time of each activity, two factors influence the adjustment factor based on the assessment of the operator who works and the allowance factor based on the time requirements such as resting to overcome fatigue and other things that cannot be avoided.

Current State Value Stream Mapping Analysis

With the Current State Value Stream Mapping that has been created, it will get a complete picture relating to the flow of goods, information, work series, along with the time of each work so that the author can quickly identify the waste or waste that exists.

In the process that occurs in the Non-Transmission Line of the K56 Gear Primary Driven product, the Supplier acts as the provider of the goods needed to carry out the production process, by sending the goods following the orders that have been requested by the Purchasing department. For the Gear-Driven K56 raw material, which is the product family in this study, the shipping process is carried out every day by the Supplier as many as 480 pcs per lot, which can then be stored on a pallet container.

Inside the Current State Value Stream Mapping, there is information about the number of cycle times and lead times of the processes that occur in the Non-Transmission Line of the Primary Driven Gear K56 product to find out how long it will take to complete each job in the process, and how long does it take to complete one cycle of the process. For cycle time, the total result of all work performed by the operator is 1,898 minutes. As for lead time, time measurements are taken when the operator does nothing or only waits. Thus the lead time obtained is eight days.

Compilation of Proposed Corrective Actions

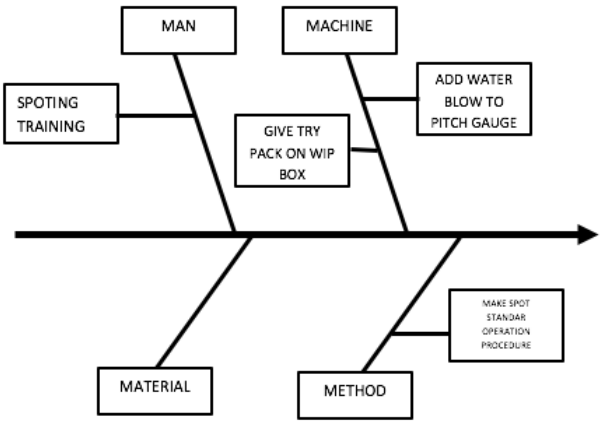

Figure 3: Fishbone Diagram after Repairing

Based on the results of the identification of the causes of the Kirikokami defect with Fishbone Diagram Analysis and waste that occurs in each process using the VSM method, it is necessary to carry out a process of improvement to reduce the non-value-added in the future so that the production process of the K56 Gear

Primary Driven product can run more effective and productive. Proposed improvement (Kaizen) Kirikokami defect can be seen in Figure 3.

After the proposed improvement is made to reduce the Kirikokami Defect with a Fishbone Diagram, then the concept of 5W + 1H (what, who, why, where, when and how) will run the PDCA wheels (plan, do, check, action) in Kaizen activities.

Table 2: Concept 5 W + 1 H

What	Factor	Why	How	When	Where	Who
Defect Kirikokami	Machine	There Is No Tool To Clean The Pitch Gauge	Provides Air Blow To Clean The Pitch Gauge From Kokami Left	15 APR 20	*LINE NON TRANSMISI GEAR PRIMARY DRIVEN K56*	Banser, Leader, Maintenance
	Method	No Spray Standardization	Make Standardization / SOP Spraying	16 APR 20		All Man Power
	Machine	Many Kirikokami WIP Box Designs Stick	Give Trypack to the WIP Box	17 APR 20		All Man Power
	Man	Operators Don't Understand Areas Where Kirikokami Is Not Available	Spraying Training was held	18 APR 20		All Man Power

Corrective Action for Every Process

Corrective actions in the Lathe, Hobbing, Chemfering, and Fine Boring processes are carried out based on the waste that has been identified previously, namely:

Table 3: Differences in Each Process

Process	Waste	Action
Lathe	Lathed parts are stored in an area without Layouts, and there is no identity label on Daisha. So Logistical Operators Difficulty when taking parts that have been in Lathe to be distributed.	Put Lot's identity on Daisha.
Hobbing	Many Daisha items that have been filled with unneeded materials are stored in the storage.	Set the number of Lot distributed on the production line.
Chemfering	Material that has been prepared is stored too long in storage so that the material becomes rusty and needs to be repaired.	Using Lot Tag (especially in the Chamfering & Fine Boring process) can determine the Minimum Stock and Maximum Stock based on the number of delivery intervals to the next process.
Fine Boring	Many Daisha has already filled with Box Material that is not needed is stored in the storage.	Eliminating storage wastage and Relayout so that each process is integrated

After the arrangement of corrective actions is made, a comparison of cycle time before and after the improvement in eliminating storage wastage and Relayout will be made to determine the effectiveness of the corrective actions can be seen in Table 4.

Table 4: Comparison of Before and After Repair Cycle Times

Process	Cycle Time (Minutes) per 480 Pcs	
	Before Repair	**After Repair**
Transfer - Lathe	5.00	5.00
Lathe Proses	513.00	513.00
Transfer- Inventory	4.00	-
Inventory	2,880.00	-
Transfer - Hobbing	4.85	3.43
Hobbing Proses	652.00	652.00
Transfer -Inspection	0.50	-
Inspection	1.00	-
Transfer - Chemfering	0.50	0.50
Chemfering Proses	413.00	413.00
Transfer-Inspection	0.50	0.50
Inspection	1.00	1.00
Transfer-Inventory	3.00	-
Inventory	2,880.00	-
Transfer- Fine Boring	2.85	2.60
Fine Boring Proses	320.00	-
Transfer -Inventory	2.20	2.20
Inventory	2,880.00	-
Total Distribution Cycle Time	10563.40	1593.23
Total Days	7.34	1.11

From table 4 is a comparison of before repair and after a repair, where the distribution time of the K56 Primary Driven Gear is shorter and more efficient. This can reduce cycle time by 663% where usually distribution time requires 440 hours and 14 minutes, after the distribution time improvement, it only takes 66 hours 36 minutes. Here is a graph of cycle time and transfer in the process. It can reduce operators by 30%, usually when distributing the Primary Driven Gear K56 requires ten operators, after repairing requires seven operators.

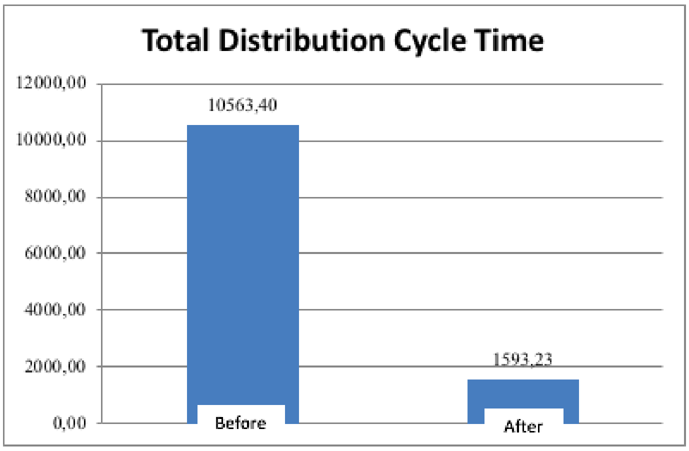

Figure 4: Time Cycle Chart Before and After Repair

Table 5: Comparison of the Number of Operators Before and After Repair

Process	Man power	
	Before	**After**
Logistic	3	2
Lathe	2	1
Hobbing	1	1
Chamfering	1	1
Fine Boring	1	1
Quality	2	1
Total	**10**	**7**

• The following is a process flow from the making of the K56 Primary Driven Gear before repair.

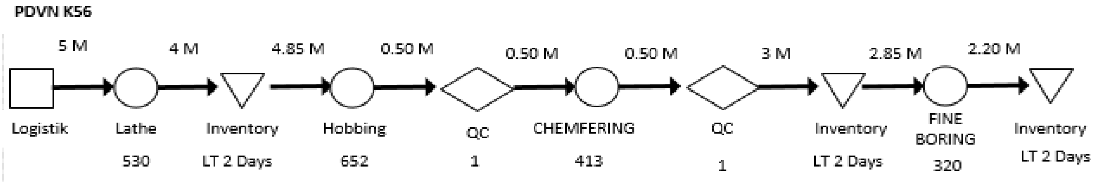

Figure 5: Process Flow Diagram before Repairing

• The following is a process flow from the making of the K56 Primary Driven Gear after repairs are made.

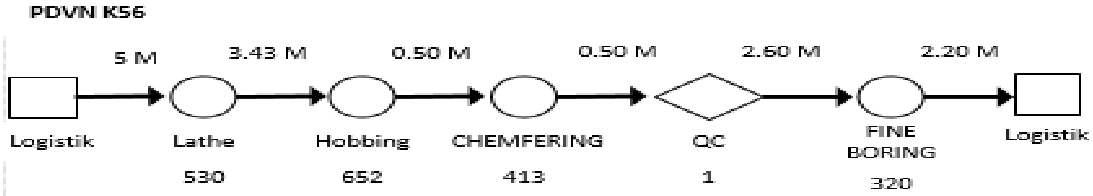

Figure 6: Process Flow Diagram after Repair

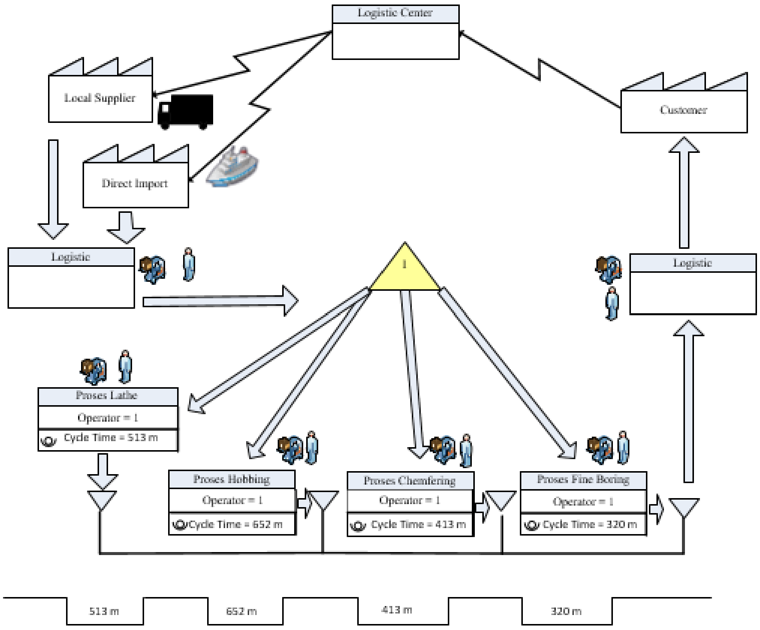

Figure 7: Future State Map of the K56 Primary Driven Gear Process

Preventive Measure

Implementing defect reduction to achieve company targets using the PDCA model (plan, do check, action) is a systematic implementation with the basic principle of continuous improvement. The PDCA principle is used as an implementation of preventive measures so that the proposed improvements that have been prepared can be maximized and effective to fix problems that occur in the company.

1. Planning (Plan)

Planning or making programs following company targets, namely eliminating defects. Example: Making an SOP for defect prevention.

2. Implementation (Do)

Carry out programs or plans that have been set at the planning stage. This stage is the most critical because it will involve all relevant departments or divisions. This stage of implementation usually refers to the program implementation schedule. Example: the implementation of retraining & introduction of the SOP or the program.

3. Check (Check)

Ensure that all programs that have been set are running following the agreed time plan. Checks can be done in the form of audits or review management. Example: Review the implementation of SOPs or programs that have been set.

4. Actions

Make improvements to the findings or deficiencies in the implementation of SOPs or programs that have been determined.

Conclusion

The following are conclusions obtained from the results of research conducted, including the following:

1. Two types of waste occur in each process in the Non-Transmission Line of the Primary Driven K56 Gear PT.XYZ products, including product defects due to the process and the length of time for distribution. From the 3-year data collected by researchers in the period 2017 - 2019, it is known that kirikokami defects are the highest defects, namely 0.61% in 2017, 0.72% in 2018, and 1.03% in 2019. This defect The result of fishbone analysis is Man, where the operator does not understand the area where there is no risk, the machine where there is no unique cleaning tool on the pitch gauge, and the method where there is no standardization for the spraying process. In the waste distribution time, obtained data that is the current distribution cycle time is 10563.40 minutes using VSM. After analyzing the proposed improvement, researchers obtained shorter distribution cycle times to 1593.23.
2. With this result, the researcher compiles a proposed improvement of 2 types of waste, namely the product defect the researcher uses the Kaizen method with a 5W + 1H analysis with the Fishbone analysis results of the proposed improvement namely Man where spraying retraining is carried out, a Machine which provides an Air Blow to clean the pitch gauge from kirikokami, Method which makes standardization / SOP spraying. In the waste time distribution, the researchers made a proposed improvement by eliminating waste
3. Storage and Relayout production of K56 Gear Primary Driven products, which can cut the number of operators by 30%.

Suggestion

Based on research that has been done, the authors feel they still have many shortcomings that have not been done. Therefore the following are some suggestions that are expected to be input in efforts to reduce waste that can occur in the future, including the following:

1. Further research can be done in identifying waste in other parts located at PT. XYZ so that every process that takes place can run effectively and efficiently.
2. Companies can continue to continuously (continuous improvement) to increase the value of work efficiency and reduce the occurrence of waste on the Non-Transmission Line Production Line of Primary Drivxen Gear products K56.

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