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WASTE REDUCTION IN BODY REPAIR & PAINT AREA TOYOTA NASMOCO RINGROAD SURAKARTA WITH LEAN MANUFACTURING APPROACH

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ABSTRACT

Toyota Nasmoco Ringroad Surakarta is a branch dealer that provides sales services, general repairs, body repair & paint, and spare parts. In the vehicle repair process, waste was found in the form of defect. The percentage of defect occurring from January to March 2020 shows an average of 85.22%. This study aims to identify critical waste defect and determine the factors that cause critical waste defect to occur and provide recommendations for improvements in order to reduce the waste that occurs in the area of body repair & paint. Efforts to reduce waste defects are carried out with a lean manufacturing approach. The research was carried out in three stages. The first stage begins with conducting a field study to identify problems. In the second stage, defect data is collected, which will be processed using Pareto diagrams so that the type of defect occurs most frequently. Furthermore, in the third stage, data processing begins with the identification of 9 wastes. Then identify the factors that cause waste using the fishbone diagram and the 5W + 1H method. Furthermore, the selected critical waste is processed using FMEA to identify systems that have a risk of failure which is indicated by the number of RPNs from the value rating of severity, occurrence, and detection. Based on the highest number of RPNs occurred in the polishing and reassying sub-area of 210. Proposals for improvement were a box, poka-yoke, and Kamishibai designs. Therefore, it is hoped that the proposed repair method will reduce the risk of defect arising during the vehicle repair process.

Keywords: *Lean manufacturing, waste, 5W+1H, FMEA, poka-yoke, Kamishibai*

INTRODUCTION

The challenges created in today's global competition have encouraged many manufacturing companies to adopt new manufacturing management methods to increase their efficiency and overall competitiveness (Nordin & Deros, 2017). A business thinks deeply about how to innovate its production process, looking for better efficiency and quality, but they often have difficulty applying it to practice (Czifra, Szabó, MĺkvaA, & Vaňová, 2019). Waste is one of the problems that often arise in every industry, where waste is an activity that causes a waste of resources but does not provide added value in an activity (Ristyowati, Muhsin, & Nurani, 2017). The existence of waste can cause losses to a company. Production processes that are less effective and efficient can result in choked up production processes and longer product processing times. Long product processing time can lead to decreased customer satisfaction. Companies need to identify waste to achieve an effective and efficient production process (Junaidi, Sandora, & Budianto, 2017).

Gaspersz (2007) states that there are 9 types of waste in a company, including transportation, inventories, motion, waiting, overproduction, overprocessing, defects, and environmental, health, and safety (EHS). According to Chrisna & Ahmad (2018), the way to reduce waste that occurs in the company is to make continuous improvements in creating output that is of good quality and does not require a lot of time to produce.

PT. New Ratna Motor is one of the five main networks of PT. Toyota Astra Motor is offering Toyota products for the Central Java and Yogyakarta Special Region. Apart from providing car unit sales services, PT. New Ratna Motor provides vehicle unit repair services (vehicle inspection). Toyota Nasmoco Ringroad Surakarta is a Toyota dealer branch owned by PT. New Ratna Motor, which is located on Jalan Raya Ring Road Mojosongo - Sroyo, Kasak, Sroyo, Jaten District, Karanganyar Regency, Central Java. Toyota Nasmoco Ringroad Surakarta provides sales services, general repairs, body repair & paint, and spare parts.

This research is focused on the area of body repair & paint because it has a greater waste than general repair areas. The body repair & paint area is a service that handles body repairs to make it look like new. This area has sub-areas including panel repair, surface preparation, masking, spraying, polishing, re-assy, finishing, and final inspection. In the process of repairing the level of vehicle damage, the body repair & paint area has 3 categories, namely lite, medium, and heavy. The lite category is a category with a light level of vehicle damage or damage to 1-3 panels. The medium category is a category with a moderate level of vehicle damage or damage more than 3 panels that do not hit the vehicle engine. Meanwhile, the heavy category has a heavy or severe level of vehicle damage to the vehicle engine. The lite category is done specifically by TPS technicians and has a target completion per vehicle of 1 hour. Meanwhile, the medium and heavy categories were done by technicians from vendors. The medium category has a completion target per vehicle of 3 - 4 days and the heavy category has a completion target per vehicle of 10 days. Based on data from January to March 2020, the body repair & paint area cumulatively handled 780 units of the lite category, 422 units of medium category, and 10 units of heavy category. This research is focused on medium and heavy categories because these categories often cause waste defects in the area of body repair & paint.

Based on the results of observations made and interviews with foremen in the body repair & paint area, it was found that the conditions were not suitable which caused waste. Waste that is found often occurs in the final inspection sub-area, where a defect occurs every month. The percentage of defects occurring from January to March 2020 showed an average of 85.22%.

The existence of a defect is indicated by the inefficiency of the work carried out by the operator, which causes a waste defect. The waste that occurs can cause the completion time to be longer than scheduled and disrupt the work process for other vehicles. Therefore, this research is focused on waste defects.

To reduce the waste that occurs in the area of body repair & paint, it is necessary to repair using the lean manufacturing method. Lean Manufacturing is a technique for designing and improving existing systems to reduce useless waste in the design, manufacturing production processes or operational services, and supply chain management (Herwindo, Udisubakti, & Anshori, 2017; Susanti, 2017). The lean manufacturing philosophy is based on the concept of minimizing non-value-added activities, reducing lead time, and minimizing production costs through continuous improvement so that problems can be overcome by eliminating waste in order to increase productivity which increases customer satisfaction in the company (Batubara & Halimuddin, 2016; Ristyowati, Muhsin, & Nurani, 2017; Pradana, Chaeron, & Khanan, 2018; Goshime, Kitaw, & Jilcha, 2019; Prabowo & Suryanto, 2019).

Some researchers try to reduce the occurrence of waste by using lean manufacturing methods including Firmansyah (2015) which uses tools such as VSM, FMEA, 5 whys, SIPOC diagrams, and AHP which are carried out in the toothpaste production process; Kusuma (2017) which uses tools such as analysis risks, activity classification, NPV, SIPOC diagrams, and BPM carried out in the fertilizer production process; Pradana, Chaeron, & Khanan (2018) which use tools such as big picture mapping, WAM, cause-effect diagrams, VALSAT, and 5W + 1H which are carried out in the paving / conblock production process; Suhardi, Anisa, & Laksono (2019) who use tools such as VSM, 5W + 1H, ECRS, and workload analysis carried out in the furniture industry.

This research is a development from previous research. The tools used in this study include Pareto diagrams, cause-effect diagrams, 5W + 1H, and FMEA. The difference in this study when compared to previous studies lies in the location of research carried out at vehicle repair shops, especially repair & paint where not many previous studies have raised this problem, efficiency in the use of tools where other researchers usually use WAM to identify waste that can actually be simplified by using Pareto diagrams, as well as proposals for improvements with Kamishibai cards that have not been used by other researchers to reduce waste. The Kamishibai cards has previously been reviewed in literature by Niederstadt (2014); Rewers, Trojanowska, & Chabowski (2016); and Knop & Ulewicz (2018).

RESEARCH METHODS

The first stage of this research begins with conducting literature studies and field studies. The literature study conducted related to the automotive industry, lean manufacturing, 9 waste, cause-effect diagrams, 5W + 1H, Failure Mode and Effect Analysis (FMEA), mistake-proofing (Poka-yoke), and Kamishibai cards. The field study phase was carried out in the Toyota Nasmoco Ringroad Surakarta area by observing the body repair & paint repair activities directly and the conditions of the work environment and conducting interviews with those who directly handle body repair & paint or foreman to find out business processes and complaints that are often experienced. Furthermore, data collection was carried out. The required data collection is defect data and the repair operation process in the body repair & paint area. Furthermore, data processing is carried out. Data processing is carried out, among others, doing waste identification with identifying nine types of waste that occur in the body repair & paint

area. The results of waste identification will be used as a consideration in determining critical waste. Furthermore, the results of the 23 types of defect data will be processed to create a Pareto diagram using Minitab 17 Software to identify problems or causes that often occur in the manufacturing or service industry so that it gets priority problem-solving. The selected critical waste defect will then be identified using a fishbone diagram. Fishbone diagrams are used as a tool to identify the root causes of complex problems (Krehbiel, 2019).

The results of the fishbone diagram are used to complete the 5W + 1H analysis to solve a problem that occurs clearly so as to obtain several alternative improvements or improvements (Siregar & Puar, 2018). The 5W + 1H analysis is done by asking what, where, who, when, why, and how. Furthermore, FMEA processing is carried out to determine the priority of the failure mode risk. Risk assessment consists of three factors, namely the level of consequences that must be accepted due to the effect of a failure mode (severity), the frequency of failure (occurrence), and the control used to detect failures before they cause certain impacts (detection) (Firmansyah, 2015; Dewi & Singgih, 2019). The formula for calculating the risk assessment can be seen in Equation 1.

$$RPN = severity\ x\ occurence\ x\ detection \quad (1)$$

After obtaining the highest RPN value from FMEA, proposals for improvement were made with Poka-yoke and Kamishibai. Poka-Yoke is a great repair tool to prevent errors from being converted to defects. In Niederstadt (2014); Knop & Ulewicz (2018), Kamishibai is a lean tool and visual management concept that is used to create, support, maintain process and stability through the use of visual signals, and verify compliance with existing standards and suitable for use in the quality inspection process. Kamishibai is designed to control work using lean manufacturing methods and is able to teach someone to find improvements that may occur in a process or position (Rewers, Trojanowska, & Chabowski, 2016).

RESULTS AND DISCUSSION

Observations are made directly on the body repair & paint area to determine the factors that cause defects during the body repair & paint process. Based on the company's historical data, there are 23 types of defects in the vehicle repair process from January-March 2020. The highest percentage of defects occurred in March at 87.67%, which indicates that rework is often carried out so that it affects the body repair & paint repair process. The defect type data is processed into a Pareto diagram using Minitab 17 Software. A Pareto diagram is a bar chart arranged in descending order of magnitude which is used to identify the problem, type of defect, or the most dominant cause so that it helps in prioritizing problem-solving in the Toyota Nasmoco Ringroad Surakarta body repair & paint area. After obtaining the Pareto diagram, then selecting the defect types that affect the waste defect.

Determination of the type of defect is based on the 80-20 principle, where 80% of the waste defect from the body repair & paint process is caused by 20% of the type of defect. Based on this principle, 5 types of defects are obtained by multiplying 23 types of defects by 20%. The five types of defects are polishing, assembling, overspray, scratch, and holes which respectively have a percentage of 26%, 20%, 10%, 7%, and 5%. The 5W + 1H analysis is a method used to solve problems so that it helps in obtaining repair alternatives. The fishbone diagram results were used to complete the 5W + 1H analysis. Based on the results of the 5W +

1H analysis, the types of defects that occur in the body repair & paint area are polishing defects, assembly defects, scratch defects, overspray defects, and holes defects. This type of defect occurs in the polishing sub-area, re-assy sub-area, masking sub-area, and spraying sub-area so that the technicians from each sub-area are fully responsible for the type of defect that occurs. This type of defect polishing occurs when sunlight is blocked by clouds, and there are many queues. Furthermore, the assembly defect type and the defect scratch type occur when there are many queues and have passed the lead time. Overspray type defects and holes occur when there are many queues.

This type of polishing defect is caused by technicians who are not careful when carrying out the repair process of body repair & paint so that they are rushed and finished, eye fatigue, less light intensity (dim light) due to using sunlight. The type of assembly defect and a scratch defect is caused by technicians who are not careful when carrying out the body repair & paint repair process, so they are rushed and finished. Furthermore, this type of defect overspray is caused by technicians who are not careful when carrying out the body repair & paint process and the masking process is less tight. In addition, this type of defect is caused by a technician who is not careful when carrying out the body repair & paint process.

Providing alternative improvements related to less light intensity (dim light) due to using sunlight, namely by using fluorescent lamps in the polishing process so that the entire vehicle body is perfectly polished. Furthermore, for alternative repairs for technicians who are less careful in carrying out the polishing, assembling, masking, and spraying processes, namely by making Poka-yoke, Kamishibai, and it is necessary to double-check by technicians and foreman before being transferred to the re-assy sub-area and finishing. The making of Poka-yoke aims to minimize the occurrence of errors by displaying the conditions before and after the repair is carried out so that technicians are more careful in carrying out the polishing, assembly, and spraying processes while for alternative repairs with Kamishibai, it aims to carry out visual checks independently so that technicians and the foreman are accustomed to distinguishing between normal and abnormal conditions during the polishing, assembling, and spraying processes.

An alternative repair related to assembling defects that are the provision of a box design to place removable parts in order to avoid scattering small parts such as nuts, bolts, clips, and so on, avoiding parts that have not been properly installed, avoiding errors in the assembly of part sides (right-left) because previously the company used a basket with cavities to place large parts and a jar without a lid for small parts. Furthermore, an alternative improvement is provided for the less dense masking process, namely the making of Kamishibai which aims to carry out visual checks independently so that technicians and foremen are used to distinguishing normal and abnormal conditions during the masking process. Identification of failure mode and effect analysis (FMEA) on the waste of defect can be seen in Table 1.

Table 1.

Failure Mode and Effect Analysis (FMEA)

No	Type of Defect	Failure Mode	Potential Effects	S	Potential Causes	O	Recommended Action	D	RPN
1	Polishing	Vehicle body rework process	Lead time completion is increased, increased production loss	7	Technicians are not careful	10	Supervise technician work regularly in areas where rework often occurs	3	210
2	Assembling			7		10	Improve communication between technicians and foremen	3	210
3	Overspray			6		8	Updating the SOP by including the correct composition of raw materials	3	144
4	Scratch			5		7	Assembly of spare parts is carried out sequentially according to the correct assembly direction	3	105
5	Holes			5		6	Periodic cleaning of the spray booth and cleaning of the vehicle body before entering the spray booth	3	90

The calculation of the RPN value is obtained by multiplying the value of severity, occurrence, detection. Based on the results of the calculations that have been done, it can be seen that the type of polishing, assembling, and overspray defect has the highest RPN successively has value of 210 and 144 so that all three are prioritized to obtain a repair.The box design for the re-assembly sub-area is used to make it easier for technicians to carry out the process of removing and installing components and to avoid lagging components. The proposed box design for the re-assembly sub-area in order to reduce the rework for installing vehicle components can be seen in Figure 1.

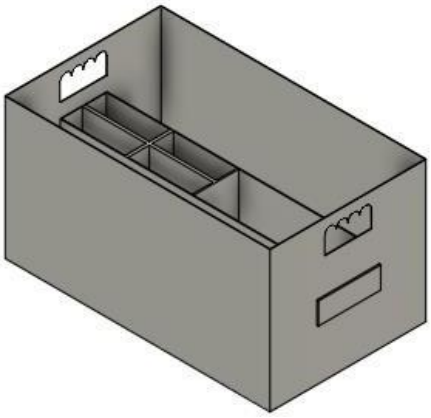

Figure 1. *Proposed Box Design for Reassembly Sub-Area*

Poka-yoke is used to prevent errors during the production process. The proposed Poka-yoke repairs carried out in the polishing and reassembling sub-areas are shown in Figure 2 and Figure 3, respectively.

Inspection Method		**Setting Function**		**Regulative Function**		**Company Name**
Source Inspection		*Contact Method*	●	*Control Method*	●	Toyota Nasmoco Ringroad Surakarta/Body Repair & Paint/Polishing
Informative Inspection (self)	●	*Constant Value Method*				
Informative Inspection (successive)		*Motion-Step Method*		*Warning Method*		
Theme Prevent polishing rework						

Before Improvement

1. Many polishes are still raw or the result of sanding is still visible
2. Fluorescent lights are only used when sunlight is blocked by clouds
3. Often the error is detected after the final inspection

After Improvement

1. Carry out independent checks of the vehicle body sequentially from right to left or left to right and from top to bottom or bottom to top with the help of fluorescent lights
2. Provision of improvement suggestions can reduce errors or errors that occur

Figure 2. *Poka-yoke proposed in Polishing Sub Area*

Inspection Method		Setting Function		Regulative Function		Company Name
Source Inspection		Contact Method	●	Control Method	●	Toyota Nasmoco Ringroad/Body Repair & Paint/Re-assy
Informative Inspection (self)	●	Constant Value Method				
Informative Inspection (successive)		Motion-Step Method		Warning Method		
Theme						
Ensure all car components are installed perfectly						

Before Improvement

1. Components are often left behind or forget to install
2. Installation of components not aligned (right or left)
3. Often the error is detected after the final inspection

After Improvement

1. Provision of improvement suggestions can reduce errors or errors that occur

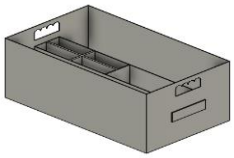

Figure 3. *Poka-yoke proposed in Re-assy Sub Area*

There are three types of Kamishibai card frequencies, namely daily, weekly, and monthly. The background color of the Kamishibai card which is blue shows the daily frequency, orange shows the weekly frequency, while the yellow color shows the monthly frequency. Each card has two sides that are green and red. The green side indicates that the task was completed on schedule. Meanwhile, the red side indicates that the task cannot be completed on schedule. This card has a size of 3 x 7 3/8 inches and uses the type of trifold card so that it is not easily damaged.

The top-right text box shows that the B / D / F group is responsible for completing work activities. The top center text box shows who the person is responsible for the work in progress. The top left box shows the Kamishibai card type. The bottom center box shows where the work process is done. Furthermore, the middle or core part of the Kamishibai card contains what tasks or activities are carried out in the production process. The bottom right box shows when the tasks in the Kamishibai card must be completed. Meanwhile, the lower-left box shows the card number that each sub-area has. Kamishibai card proposal for daily frequency is shown in Figure 4. The proposed Kamishibai card for weekly frequency is shown in Figure 5. The proposed Kamishibai card for monthly frequency is shown in Figure 6.

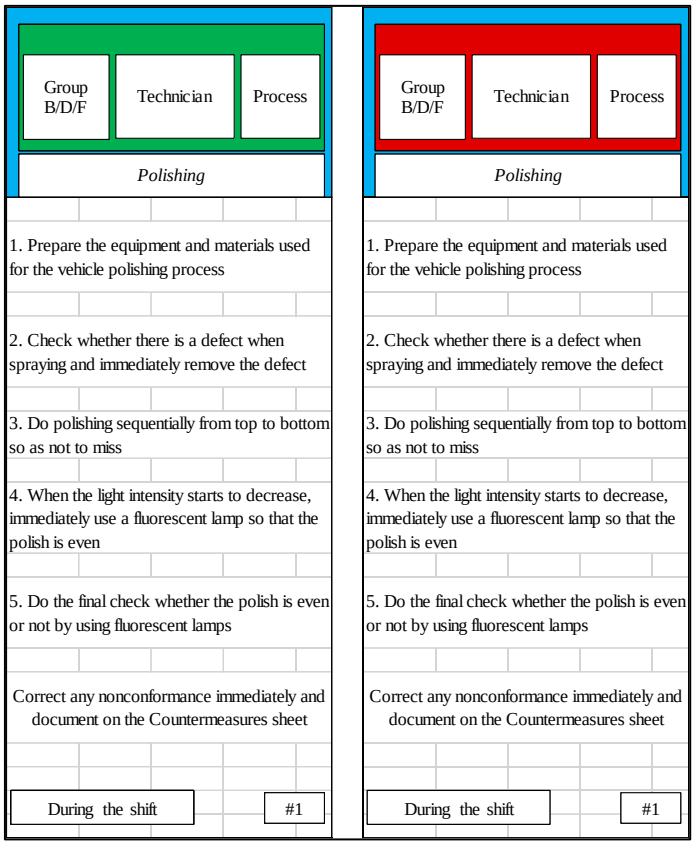

Figure 4. *Daily Frequency Kamishibai Card*

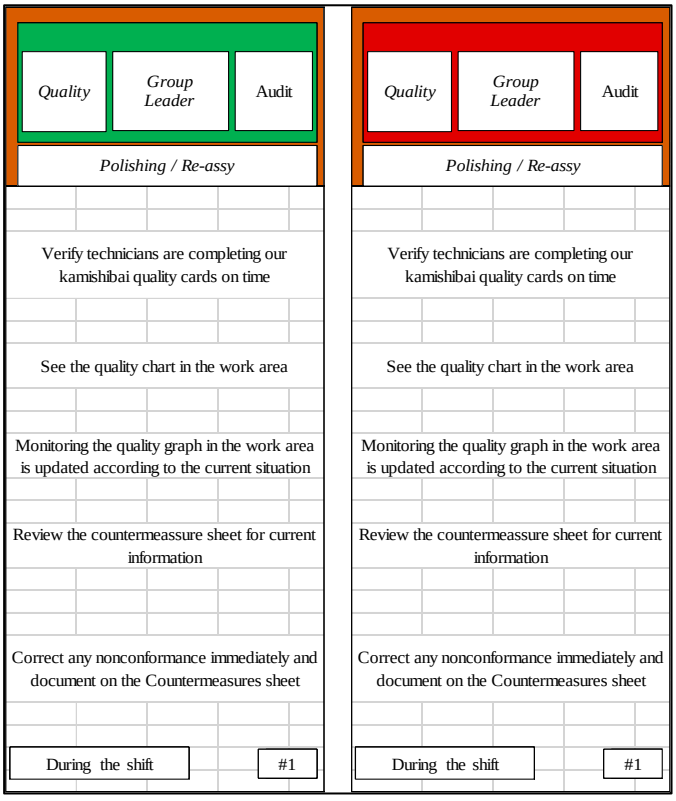

Figure 5. *Weekly Frequency Kamishibai Card*

Figure 6. *Monthly Frequency Kamishibai Card*

If the audit process is carried out properly, the cards on the Kamishibai board shelf are replaced with green sides; if the audit conducted is unsuitable or not complied with then the card is returned to the rack showing the red color. Non-conformities are documented on the Countermeasure sheet or countermeasures sheet. When there are no more cards in the box, it indicates that the process has been checked. All cards are removed from the rack and placed back into the box then start the process all over. Any problems that were resolved on restarting the process should be identified with a red circle. The Kamishibai system works effectively because everything can be seen clearly and can assess normal or abnormal conditions.

CONCLUSION

Based on the results of the research that has been done, it is concluded that the critical waste that occurs in the body repair & paint area at the Toyota Nasmoco Ringroad Surakarta is waste defect. Based on the results of data processing, it is known that the factors that cause waste defects (rework) in the body repair & paint area at the Toyota Nasmoco Ringroad Surakarta using the 5W + 1H analysis are operator inaccuracy, the eyes become tired quickly due to less light intensity, and the use of sunlight does not maximize performance due to poor lighting. Another reason is that operators are in a hurry because they want to finish the job immediately and have passed the lead time, as well as the many queues of vehicles that want to be repaired immediately. In addition, the masking process is less dense due to saving raw materials. Proposed improvements made to reduce the occurrence of waste are in the form of box designs,

Poka-yoke, and Kamishibai cards in the polishing and reassy sub-areas which are the source of the highest waste. In this study, the proposed improvements are expected to reduce the waste defect that occurs so as not to cause production loss. Further research is expected to implement the suggestions given and compare the results after improvements and develop other lean manufacturing concepts with more efficient methods so that they can adapt to the industrial era 4.0.

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