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Improvement Design of Cover Nut Production Process Using Lean Manufacturing Approach To Reduce Rework Activities

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Abstract. PT. NAGOYA is a company engaged in the rubber, polyvinyl chloride and plastic industry. PT. NAGOYA producing spare parts made from rubber for the needs of movable vehicles, such as seal switches, lever seals, safety regulators, seal buttons, R3, cover nuts, water reservoir tank caps, seal bracket, rubber discs, rubber dumper. Among all the products produced during the research, namely the seal switch, cover nut, seal bracket, and K3, the cover nut has the longest lead time, which is 71 minutes, there is a difference for 48 minutes with seal bracket, which is the most produced product. After further analysis, in the production process of cover nut, there is a reworked activity caused by waste defects in the cutting area. Cutting area has the highest defect value compared to other areas in the cover nut production process as much as 86.67%. The waste defect caused by an unsuitable result of cutting the compound. Efforts are being made to minimize waste defects and eliminate rework activities using lean manufacturing. Creating value stream mapping (VSM) and Process Activity Mapping (PAM) to map the flow of information and the flow of the production process. Next, identify the root of the waste defect using 5 whys. The problem of the waste defect will be solved by improving the design of cutting tools using the quality function deployment method and improving the system to the automatic using controller. After that, creating value stream mapping (VSM) current state and compared to value stream mapping (VSM) future state to find out the differences that occur after the implementation of the proposed design. The result obtained from the proposed design is stable cutting result caused by an automatic system so defects will be reduced and will eliminate rework activities in the cover nut production process at PT. NAGOYA so the production lead time will be reduced by 280,063 seconds or 8%.

Keywords: lean manufacturing, quality function deployment method, waste defect, controller, rubber

1. INTRODUCTION

PT. NAGOYA is a company engaged in the rubber, PVC and plastic industry. It was established in 1997 with the form of a Joint Commissioner (CV) which was legalized in 2002. The system used by PT. NAGOYA is make to stock, meaning that the company manufactures products for inventory not based on consumer demand but based on forecasts made by the consumers themselves. PT. NAGOYA manufactures rubber-based spare parts for the needs of motorized vehicles, such as such as seal switch, seal lever, safety regulator, seal button, R3, cover nut, cap water reservoir tank, seal brecket, rubber disk, rubber molla, rubber dumper, etc. (Pratama, 2018) Based on observations, among the many products manufactured, the cover nut had a longer cycle time compared to other products because in the production process of making cover nuts, there were rework activities that hinder the flow of the production process. The production lead time for the cover nut was 71 minutes. While the lead time for making other products, such as the seal switch was 23 minutes. There was a 48 minute difference between the lead time of the cover nut production process and the seal switch.

The cover nut production process went through six processes, such as inspection 1, compaction, cutting, inspection 2 and rework, pressing then finishing and inspection 3. From the entire process to do the cover nut production, it was found that the highest defect was in the cutting process that can be seen in Figure 1.

The cause of the defect is the unsuitable cutting compound result so it is necessary to do rework activities. Rework is a non value-added activity. Rework is one of company's effort to be able to adjust product quality to standards according to consumer demand. However, on the other hand the process of the rework impedes the flow of material processes, where output in a process, at the same time becomes input for the next process. (Szewieczek, 2009) This cannot work properly because there is work on

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rework in the middle of the process flow. In addition, it can lead to expenses that are not expected by the company due to the material, time and energy that is wasted (waste).

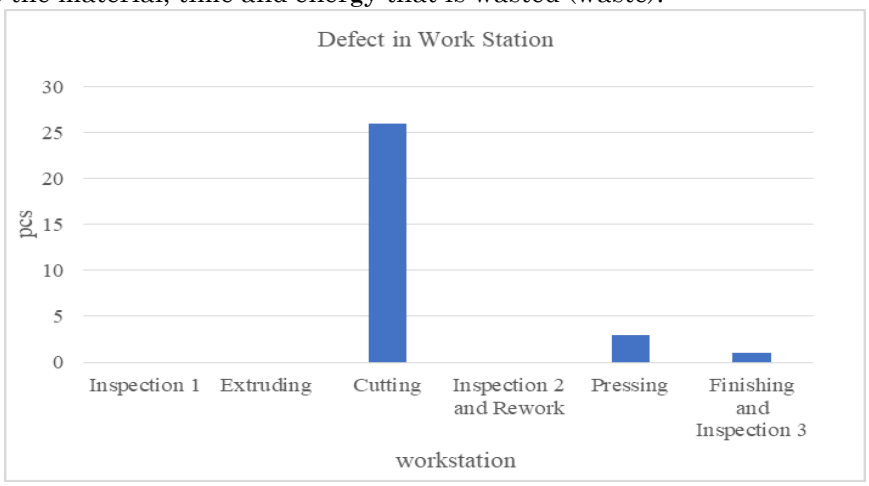

Fig. 1: Defect in every workstation

Product development in production equipment using the method of Quality Function Deployment (QFD) that is tailored to the needs of production appropriately that can reduce waste defect. Therefore, this study will design a proposed improvement in the form of automatic cutting tool design to reduce rework on cover nut production that occurs due to waste defect in the form of unsuitable compound cutting result at PT. NAGOYA using the Quality Function Deployment (QFD) method.

2. LITERATURE REVIEW AND RESEARCH METHODOLOGY

2.1. Lean Manufacturing

Lean is an approach to reduce operational costs by checking all forms of waste from the customer's perspective. Each activity is categorized as value added activities and non-value added activities. Every process that is not value added from the customer's perspective must be eliminated. Lean Manufacturing is a systematic approach to identifying and eliminating waste with continuous continuous improvement techniques. (Franchetti, 2015).

Tools that used in lean manufacturing, such as:

1. Value Stream Mapping

   VSM is a lean manufacturing technique that is used to visualize the flow of a service, product or information. This provides a system of views on workflows involving many processes in traditional process mapping techniques through the use of symbols to convey information concisely (Locher, 2008).

2. Process Activity Mapping

   PAM is a map that is used to describe in detail the processes that occur when the product is made. In PAM there is information such as operation with symbols (O), inspection with symbols (I), transportation with symbols (T), storage with symbols (S), and delay with a symbol (D) (Antony, 2016).

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3. 5 Whys

5 Whys are used to determine the root cause of a problem where the problem involves human factors (Antony, 2016).

4. 5W+1H

5W + 1H is a method used to collect and present information using six basic questions to get information, namely: what, where, when, why, who and how (Vontana, 2011).

2.2. Waste

Waste is any activity where the customer is not willing to pay for the activity. In general, it can be classified with value added activities and non-value added activities (Voehl, et al., 2014).

2.3. Operation Process Chart

OPC or process map is a graphical tool that represents each process in pictorial representation. If modifications are made to the process, the process map is a tool that is useful in communicating the changes proposed to the process in the system. The process map uses flowcharts and flow diagrams (Womack & Jones, 2015).

2.4. Programmable Logic Controller

Programmable Logic Controller (PLC) is basically a computer specifically designed to control a process or machine. This controlled process can be in the form of continuous variable regulation such as servo systems or only involves the control of two conditions (On/Off) only but carried out repeatedly as we generally encounter drilling machines, conveyor systems and so on.

2.5. Research Methodology

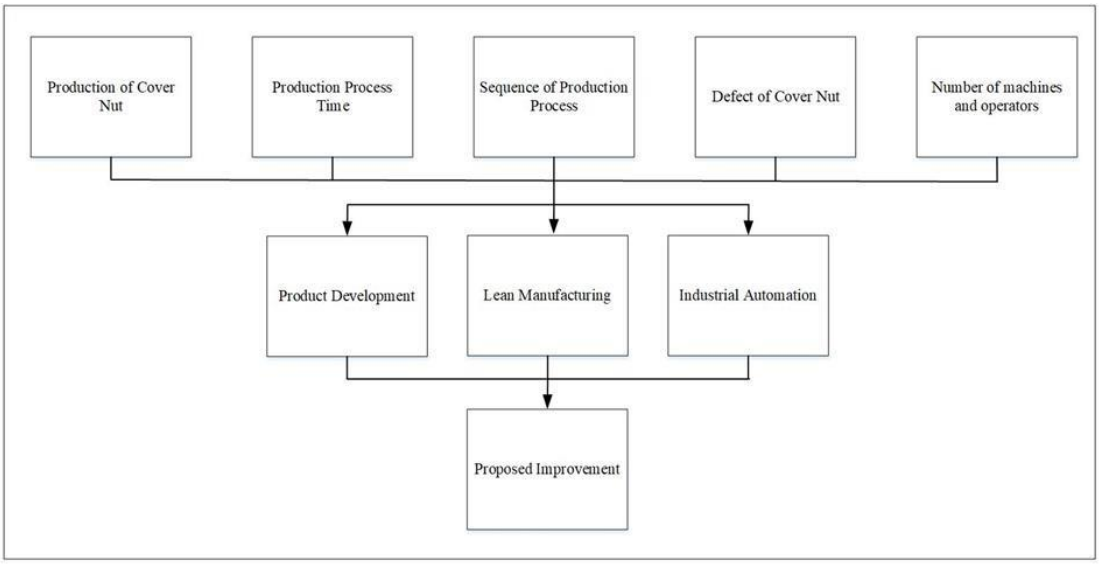

Fig. 2: Conceptual Model

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Based on Figure 2 Conceptual Model, it can be seen that the data needed to solve problems at PT. NAGOYA is production process time, production process sequence, cover nut production data, and number of machines and number of operators. The data will be used as information and input on the analysis of the problems that occur and to find out the production process and information flow that occurs during the cover nut production process that will be made into the value stream mapping and process activity mapping to analyze waste that occurs as one tools on Lean Manufacturing.

3. DISCUSSION

3.1. Waste Defect Cause Identification

Observation made at PT. NAGOYA had one of goals which was to find the cause of rework in the production process of Cover Nut products. Based on observations made, the cover nut product had a longer cycle time compared to other products. This was due to rework activity which was a non value added activity. The rework activity was done because the product manufactured in the previous process, namely the cutting process, was not suitable with what was supposed to be so the rework process was needed to proceed to the pressing process.

3.2. Identification of root problems using 5 whys

Based on the observation result, the waste defect produced in the cutting area was 87%. The root cause of this waste can be analyzed with 5 Whys which can be seen in Table 1. It is found that the root cause of defect in the tools side is the compound density, from the method point of view the products are through cutting processes vary and from the man side is the operator performs activities that do not need to like chatting, daydreaming and looking in various directions.

Table 1: 5 whys analysis

Defect	*Cause*	*Sub Cause*	*Why*	*Why*	*Why*
Unsuitable compound cutting result	Tools	Marking does not help in production	Marking is not accurate so it does not guarantee the suitable weight of compound	Not adjusted to the solid thickness of the compound	Compound density vary
	Method	Not all operators cut according to marking	A lot of marking on the tool cuts and cannot be distinguished	Products which are through the cutting process are vary	
	Man	Indiscipline operator	Doing unnecessary activities like chatting, daydreaming and looking in various directions		

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3.3. Improvement Proposal

Based on the identification of waste defect cause in the cutting work station, it was found problems that had an impact on the production process result. These activities affected product quality due to defects and longer cycle times. Therefore it is necessary to improve the cover nut production process in the cutting work station using a lean manufacturing approach.

Table 2: Improvement Proposal

Problem	Root Cause	Proposal
Unsuitable compound cutting result	The tools used in the cutting process in the rubber strip cutter machine in the form of marking made using tipe-x or masking tape do not help workers in cutting activities because the marking that is made inaccurate so it does not guarantee the suitable compound weight.	Design of cutting systems with automatic systems to cut compounds using Programmable Logic Control (PLC).

a. Cutting Tools Design

The cutting tools were designed using a scoring matrix concept by paying attention to the mission statement and need statement as the development concept. After that, the selection of several product concepts and then the screening was done using the scoring matrix concept so that the product concept was chosen for the design of cutting tools. Figure 3 is the chosen concept for cutting tools design. Analysis of cutting tool design can be seen in Table 3.

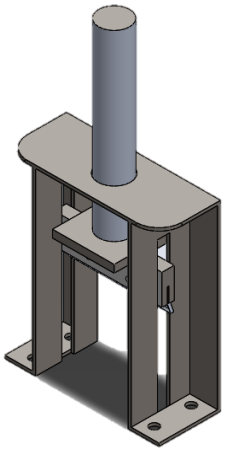

Fig. 3: Design of the cutting tools

The following is an analysis of the advantages and disadvantages of cutting tools design.

Table 3: Analysis of the cutting tool's design

Advantages	Disadvantages

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This cutting tool is designed simply to be easily adjusted and easily repaired by the operator during repairs (maintenance). The knife component has a material that is resistant to rust and corrosion while maintaining its sharpness for a long time.	This design is custom that is tailored to the needs of the company so reservations must be made in advance to get this cutting tool.

b. Design of the work system

Figure 4 is the result of a series of ladder diagram that have been simulated. There are five inputs and three outputs in this series which can be seen in table 4. The flowchart of the system work process can be seen in Figure 5.

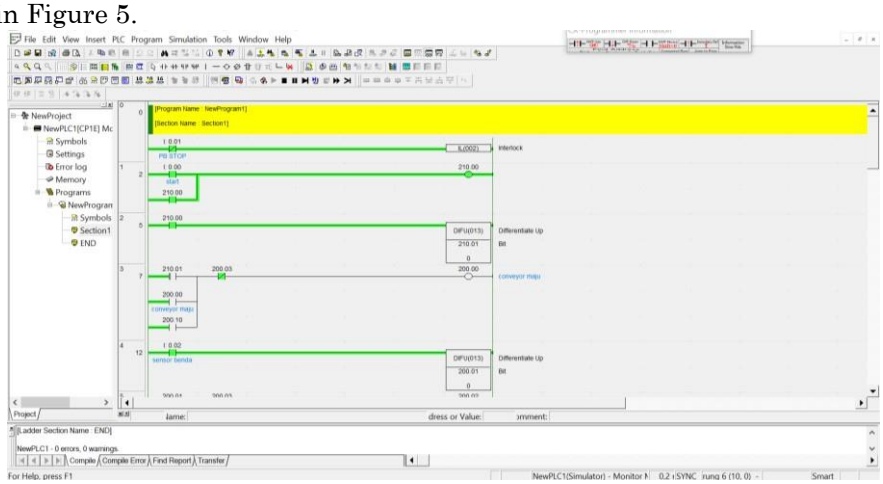

Fig. 4: Ladder Diagram

Table 4: Input and Ouput on PLC

Input	0.00	Start
	0.01	Stop
	0.02	Sensor
	0.03	Limit Switch Down
	0.04	Limit Switch Up
Ouput	100.00	Conveyor On
	100.01	Cutting Down
	100.02	Cutting Up

The following is a system work process flowchart created.

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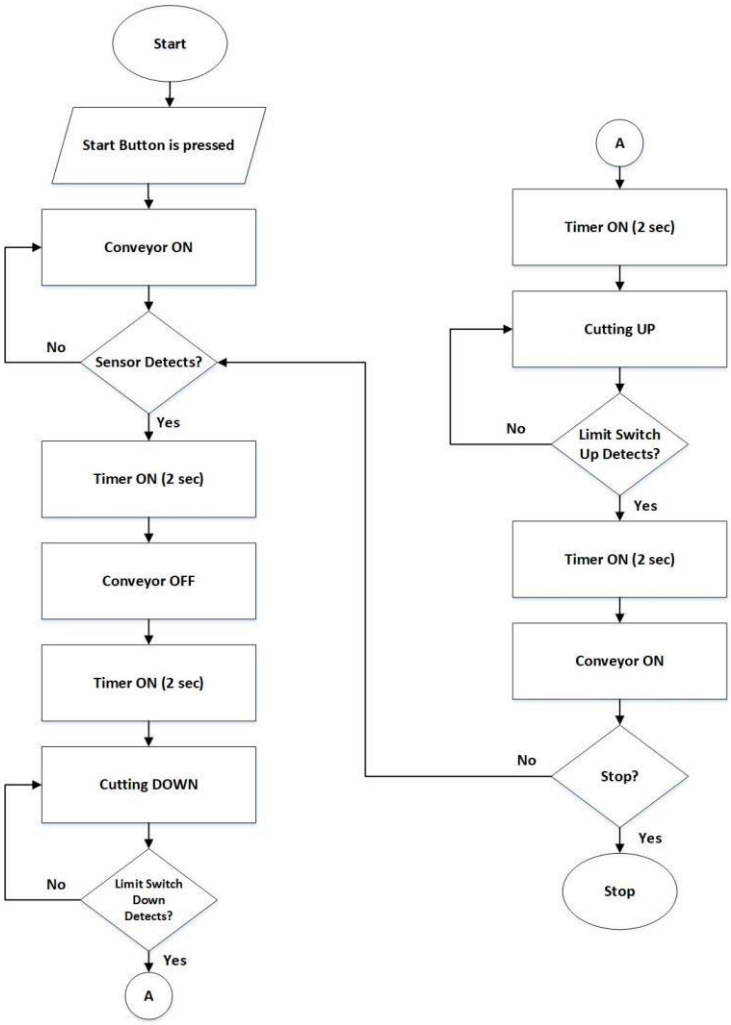

Fig. 5: Working System's flowchart

Analysis of the advantages and disadvantages of Automatic Cutting Tools can be seen in the following table.

Table 5: Analysis of the advantages and disadvantages of Automatic Cutting Tools

Factor	*Machine*	
Problem	The results of cutting the compound are not appropriate	
Root Cause	The tools used in the cutting process on rubber strip cutting machines are less effective and efficient	
Proposal	Design of cutting systems with automatic systems to cut compounds using Programmable Logic Control (PLC)	
Kelebihan		Kekurangan
1. The results of compound cuts are more accurate with the appropriate length and weight. 2. Automatic systems can reduce the workers load. 3. Reducing two work stations, namely cutting and reworking.		1. The price of a PLC is not cheap so the company has to pay more.

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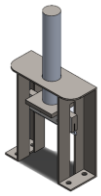
The design of the proposed production aids in the form of automatic cutting tools is an improvement carried out in this study. The following is a comparison between the existing cutting tools and the proposed cutting tool design.

Table 6: Comparison of Existing and Proposals Cutting Tools

Existing	Proposal
	
Dimention : 560 x 670 x 132 mm	Dimention : 100 x 40 x 120 mm
Weight : ± 5 kg	Weight : ± 2 kg
Material : Iron	Material : Steel
Working System : Manually	Working System : Automatic
Number of Components : 35	Number of Components : 3

4. CONCLUSION

Based on the research that has been done in the company, it can be concluded that the waste defect cause studied in the cover nut production process is the result of cutting a compound which weight is not in accordance with the specified weight so the rework must be done. The factors that cause waste defects analyzed using 5 Whys include machine factors (marking does not help in production because marking is inaccurate so the results are not suitable), man factor (not all operators cut according to marking because there are many markings and products vary) and factors method (operator is not disciplined by carrying out unnecessary activities). Proposed improvements are made to overcome the problem of compound piece weight mismatch that occurs in the cover nut production process by making improvements to cutting tools at this time. The proposed tool uses a work system automatically so that it does not need an operator and the results of the cuts are stable. This tool will help the production process more quickly by reducing production lead time by 280.063 seconds or by 8% because it will eliminate rework activities and produce the appropriate cutting result so that waste defect is expected to be reduced due to using automatic systems.

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