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Implementation of Lean Manufacturing for Increasing the Quality of Aluminum Conductor Products in the Stranding Process with the DMAIC and VSM Method Approach: A Case Study in Electrical Manufacturing Component

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ABSTRACT

Electrical Company in this study is a manufacturing company engaged in the cable industry and one of the products it produces is an aluminum conductor. The current situation shows that the quality of aluminum conductor products still does not meet the company's standards. This can be seen from the production output data for the period June 2021 – November 2021 where the percentage of aluminum conductor product faiures exceeds the set target of 1.50%. The purpose of this research is to implement lean manufacturing to improve the quality of aluminum conductor products using the DMAIC (Define, Measure, Analyze, Improve, Control) and VSM (Value Stream Mapping) methods. The expected result of this research is an increase in product quality.

Keywords: Defect, DMAIC, Quality Characteristics, Six Sigma, *Value Stream Mapping* (VSM).

1. INTRODUCTION

The development of technology and information in this millennial era is growing very rapidly, when companies also have to create sophisticated methods and technology to keep up with the times. On the other hand, companies must also demand good quality to serve and meet consumer needs. And expectations from consumers that the resulting product has a good condition and is suitable for use. Therefore, companies must pay attention and apply the best methods to maintain the quality of the products produced and accepted by consumers that these products can compete in the market.

Quality problems have led to the company's overall tactics and strategies in order to be competitive and survive global competition with other company's products [1-14]. The quality of a product is not a coincidence, quality can be interpreted as the level or measure of the suitability of a product with its users or from a different point of view, quality means the level of conformity of the product with the standards that have been set [15-21]. Quality control in companies both in the service sector and in the manufacturing sector is very necessary. The goal of quality control is to quickly investigate the causes or shifts in a process such that an investigation of the process and corrective action can be taken before too many nonconforming units are produced [22-27].

Every company has a quality control function which is usually carried out by the quality control department, but in the company the quality control or supervision department does not always exist depending on the size of a company and the type of product produced by the company. A product produced by a company can have a large enough impact, especially to maintain competitiveness in the global world.

To evaluate the quality of the production process, identify the causes of defective products, and find alternative solutions to improve the quality of the production process, a method is needed, namely Six Sigma [28-30]..The Six Sigma method is a philosophy that requires that the products produced are only allowed to have a number of defects of 3.4 defects per 1,000,000 products to be able to meet the production process that has met the Six Sigma level or in other words the OK Ratio level of the product is 99% [31-36].

In addition to quality, companies should also consider efficiency to increase productivity by reducing activities that have no added value or what is known as waste. Companies must look for changes to create continuous improvement by carrying out production efficiency to reduce activities that have no added value or waste. The emergence of waste can cause a decrease in income if it is related to costs and also a decrease in customer loyalty. Therefore, companies must focus on effective quality improvements to reduce the occurrence or occurrence of such waste. To implement continuous improvement, an approach that can be used correctly is needed so that continuous improvement can be realized.

Electical Company in this study is one of the manufacturing companies engaged in the cable industry and includes a free market cable supplier in national to international scope for main contractors and distributors such as PT. PLN PERSERO, PT. WASKITA WORKS, and others. One of the products made by PT Voksel Electric is Aluminum Conductor. Therefore, quality is one of the important factors that must be maintained by this compant to increase their competitiveness and loyalty to their customers.

Figure 1 Aluminum Conductor In Wooden Drum

Aluminum conductors are 7 or more aluminum wires with the same nominal diameter twisted together in concentric layers. When a conductor consists of more than one layer, successive layers of the other are twisted in opposite directions defined as the right-hand gyre step (Z) and the left-hand gyre step (S). A process that creates 7 aluminum wires that are twisted together in concentric layers continuously or continuously to form a twisted conductor driven by a stranding machine.

From production output data taken in June 2021 - Nov 2021, there are still Aluminum Conductor (ALC) products that do not meet the standard. The following is a table of production data for Aluminum Conductor products.

Table 1 Production Output Data and Aluminum Conductor Product Files

Month	ALC Production Output /Meter	Data Failures (Product Not Conforming to Standards/Meter)	% of Failures
June	1521	14	0,92
July	1184	37	3,13
August	796	16	2,01
September	954	19	1,99
October	681	43	6,31
November	618	31	5,02
Total	5754	160	19,38

Product files are products that are not in accordance with production standards that can still be reworked. If this happens to the customer, the customer will also complain or return the product so that it can be reworked until the product meets their needs (customers).

Based on the results of interviews with the aluminum conductor production supervisor, the company has set an output target of 1.50% for aluminum conductors. From the production output data (table 1) and the graph above (graph 1.2), there are still

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Aluminum Conductor products that have not reached company standards and have the highest percentage of failures in May 2020 of 6.31% with a length of 43 meters. It can be concluded that there are still product files that do not meet the standards and must be identified further by conducting quality control.

From the results of [31], with the title increasing company productivity using the six sigma, lean and kaizen methods, it was found that productivity increases can be done using the six sigma, lean and kaizen methods by reducing work process time, work in process and lead time of the production process through waste elimination. Therefore, it is necessary to find a way to minimize Aluminum Conductor product files. In this study, the Define-Measure-Analyze-Improve-Control (DMAIC) and Value Stream Mapping (VSM) approaches will be used to improve quality and determine the causes of product failureure and waste in the Stranding process on Aluminum Conductor products.

2. RESEARCH METHOD

1. Define stage

At this stage, we will explain the SIPOC flow chart (Supplier-Input-Process-Output-Customers). Furthermore, the current production conditions will be mapped using CVSM (Current Value Stream Mapping), and analyze the causes of product failure types using Critical To Quality.

2. Stage Measure

• Measurement of Time Value Added (VA) and Non Value Added (NVA)

It is a measurement of work activity time in aluminum conductor production processes.

• Defects per Opportunity (DPO)

It is a failureure measure showing one defect per opportunity.

• Defects per Million Opportunities (DPMO) calculation

A measure of failureure that shows the number of defects per million opportunities.

• Finding the Sigma Quality Level (SQL) value

It is an indicator that describes the level of process performance, and to find the sigma value in the stranding process.

• P Control Map (p-chart)

Is an indicator that describes the quality control limits on aluminum conductor products.

3. Analyze Stage

At this stage, the root cause of the problem and the source of the product failure is determined by using the following tools:

• Pareto Charts

Pareto diagrams are used to determine the most dominant file types.

• Fishbone Charts

Fishbone diagram is used to analyze the cause of the failureure.

4. Improve stage

In the improve stage, tools are used to make improvements to the occurrence of files, namely:

• 5W+1H

5W+1H is used to find the best solution by answering the questions on the cause of the failureure of the aluminum conductor product.

5. Stage Control

At this stage the application of correct work standards needs to be controlled and set as optimally as possible so that quality control does not decrease in performance as management changes in the company.

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3. RESULT

Define

The problem discussed in this study is about the failure on the Aluminum Conductor product. The discussion is as follows:

Table 2 Aluminum Conductor Product File Type

No	Failureure type	Total Failureures (Meter)
1	Broken Wire	96
2	Not Smooth Visual	33
3	Dimension	16
4	Less Conductor Length	15
Total		160

Based on the table, the results of the assessment of 4 types of aluminum conductor product files. The one with the highest file value is found in the product file type on the broken wire by 60%.

SIPOC Chart

This SIPOC (Supplier, Input, Process, Output, Customer) analysis is very useful for knowing and identifying who is the supplier for input to the process, what specifications will be used for input, what processes are used and the quality of the product desired by the customer. customers (customers).

A. Supplier

Supplier Is a unit that acts to fulfill or supply raw materials in the manufacture of Aluminum Conductor products.

1. PT. Inalum

2. PT. Hengtong

3. PT. Walsin

It can be seen that suppliers of raw materials for Aluminum Conductor products come from local and import companies or foreign companies.

B. Input

The materials used are;

1. Aluminum Ingot, is a pure aluminum metal material such as gold bars in the form of boxes.

2. Magnesium

3. Silicone

4.Zirconium, is a mixed material (alloy) which is used to change the hard properties of aluminum to be cast into castbar.

5. Water Blocking Powder, is a material shaped like salt powder which is used to prevent overheating of the conductor.

6. Steel Core, is the core layer on the conductor for certain types of conductors.

C. Process

Based on analysis and observation, there are 7 stages in the manufacture of aluminum conductor products:

1. Melting

2. Holding

3. Casting

4. Rolling

5. Cooling

6. Drawing

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7. Stranding

D. Output

Production results are carried out after going through several processes ranging from raw materials to finished products and quality inspections for product quality to checking labels and product types in the packaging area.

E. Customer

Aluminum conductor products that have passed the product quality inspection until they pass the packaging inspection, will be distributed by the delivery team .

Current Value Stream Mapping Aluminum Conductor

The following is an explanation of the symbols on the Current Value Stream Mapping Aluminum Conductor:

1. A/T (Available Time)

Is information on the normal working time required in changing work shifts

2. C/O (Change Over Time)

It is information on the operator's work shift time continuously with a total of 24 hours of work

Measure

From the results of the identification of waste, it is known that there are activities that do not have added value (non-value added) that cause waste to occur with the type of waste category, namely waiting and motion, the explanation is as follows:

1. Types of waste waiting

The reason is because of the activity on the forklift carrying aluminum coil material which takes 4 minutes from the cooling process to the drawing process. Then the type of waste waiting is followed by an activity in quality control which performs quality checks on the process of twisting the aluminum conductor in the stranding machine before it is declared OK to continue the process.

2. Types of waste motion

The reason is that the operator's work activities are excessive and repetitive so that it takes a long time before running the process, such as preparing/pushing the supply material bobbins from the drawing process, then carrying out work activities on splicing supplies as many as 54 bobbins in the stranding machine which is called -loading- unloading cage or raising process material.

From the results of calculations for DPMO in Table 4.8, it can be seen that the average sigma level of Aluminum Conductor products based on production data and product files is 4.15 sigma, it can be concluded that the company has not implemented quality control with an effective six sigma method to achieve target value 6 sigma.

Then the results of the calculations on the control chart (p chart)) in Figure 4.6, it can be concluded based on the production data and product files for the period January 2020 – June 2020 that the quality control of the aluminum conductor product is still not within the overall control limits.

Analyze

At the Analyze stage, an analysis is carried out to find out what causes the current problems so that repairs can be made quickly and precisely, for this stage the tools used, namely the Pareto Diagram, functions to determine the most dominant file types in Aluminum Conductor products. So that improvements can be focused on the types of files that are obtained. In addition, Fishbone Diagram tools are used to be able to find the causes of these files. Pareto chart

Pareto diagram is a tool used to find the cause of a problem or damage to a product by getting the highest damage data and to be able to focus repairs on the most dominant problem. it can be concluded that the dominant product type of aluminum conductor product with the highest percentage is the type of broken wire failure at 60%.

Improve

At the improve stage using 5W+1H tools (what, why, where, when, who, how) as a proposed improvement, based on the results of table 4.11 5W+1H, conclusions can be drawn for the prevention and quality control of aluminum conductor products by making process disturbance reports. for further corrective action and continuous improvement to minimize damage to the machine. And also obtained suggestions for improvement or brainstorming on the cause, namely by making sensors on the machine as an early prevention before the damage that occurs becomes more severe.

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Control

At this stage of control itself is a phase that aims to control the process as it should be so that it runs according to the initial goal and is expected to at least reduce the problem or what has happened does not happen again. For this control stage, several action steps are taken to minimize the occurrence of product failureures, namely by carrying out maintenance with a more intense time or more often, maybe at least 3 times a week inspection and maintenance, then making a proposal for an aluminum conductor product quality inspection sheet for process monitoring. that takes place so that the checking can run optimally.

4. CONCLUSION

Based on the results of the discussion, the authors conclude the results of the implementation of quality control using the DMAIC (define, measure, analyze, improve, control) and VSM (Value Stream Mapping) aluminum conductor products as follows:

1. Based on the results of the analysis of the dominant type of product file on the aluminum conductor product using the Pareto diagram, there are several types of aluminum conductor product files, namely, 60% of wire breaks, 10% dimension, 20.63% visual imperfection, and conductor length less by 9.38%. Meanwhile, based on the identification of the type of waste from the results of the calculation of time VA (value added) and NVA (non value added) it has been concluded that there are activities that do not have added (non-value added) in the aluminum conductor production process with categories of types of waste, namely, waiting and motion.

2. Based on the results of the analysis on the aluminum conductor product file using a fishbone diagram, there are factors that often cause failureure in the aluminum conductor production process, namely, human (man), machine (machine), method (method), raw material (material)), and the environment (environment).

3. Based on the analysis, the proposed improvement by using 5W+1H on the type of broken wire failure (the highest failure) found in the stranding process on aluminum conductor products is to make improvements or provide suggestions for planning the manufacture of sensors on the machine as an early prevention before the damage occurs. more severe and the proposal to make a process disruption report as an initiative step for further corrective action.

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