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Manufacturing Continuous Improvement of Busbar Product Using Six Sigma Approach At PT. XYZ

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Abstract— PT. XYZ is a manufacturing company engaged in the production of cables and conductors such as busbars. Busbar is a copper bar used to distribute electric power. The problem that occurs at PT. X is that there are still reject products in the busbar production The reject criteria found are as follows: bent busbar, scratched visual, oxidized visual, cracked visual during bending test. This aims of this research are to reduce the total rejects in busbar products by proposing improvements to the busbar production process using the six-sigma method. The data used in this study consisted of primary data (results of discussions with production managers, quality control managers and engineering staff and research in field) and secondary data types and total rejects within 21 months. The results of this research found that at the define stage scratched busbar and bent busbar are the dominant type of busbar that will be improved in this research. At the measure stage, the company sigma value is 3.607. This result can be used to propose quality improvement for the busbar production process whisch is obtained so that the company can reduce the number of defective products and improve product quality.

Keywords: Quality Control, Six Sigma, Busbar, FMEA.

1. Introduction

PT. XYZ is a manufacturing company engaged in the production of cables and conductors. which located at West Java. Some of customers of this company is the domestic market which includes Indonesia stated-owned companies, such as PT. PLN (Electricity) and PT. Pertamina (Migas), as well as international countries such as the United States, Myanmar, Iraq, Mozambique, Timor Leste, and many others. Cable directors produce types of conductor products, low voltage power cables, overhead conductor cables, copper, medium voltage power cables, aluminum medium voltage power cables, medium voltage twisted cables and high voltage cables.

To achieve a standard of excellence in providing products and services, PT. XYZ continues to implement a quality management system and obtain certification for domestic and international standards. PT. XYZ has been certified ISO 9001: 2008 for quality excellence, ISO 14001: 2004 for the company's commitment to environmental management, and OHSAS 18001: 2007 for controlling and improving health and safety performance. All products are made using the latest technology, which is designed according to applicable standards and requirements, and developed by trained and professional people to ensure customer satisfaction. Cables produced by PT. XYZ are by SPLN LMK or SNI (Indonesian Standard), and meet the following standards: International Electrotechnical Commission (IEC), American Society for Testing and Materials (ASTM), British Standards (BS), National Electrical Manufacturers Association (NEMA), Japanese Industrial Standards (JIS), Deutsches Institut für Normung (DIN), Insulated Cable Engineers Association (ICEA), Verband der

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Busbars are strips or rods made of copper or aluminum that are usually placed inside the panel boards and the switchgear for high current power distribution. Copper busbar is better than aluminum busbar in terms of conductivity and strength. However, copper weighs more than aluminum. Copper has a higher level of hardness and thus provides greater resistance than aluminum so that a busbar made of copper is more resistant to damage. PT. XYZ produces a busbar that made from copper. Busbar is defined as a group of conductors used to collect electric power from the incoming feeder and distribute it to to all branches of the protection circuit in an electrical installation. In other words, busbar is a type of electrical connection where all of the incoming and outgoing electric currents meet. Busbars can also connect high-voltage equipment to electrical switchyards and low-voltage equipment to battery banks. This research was only conducted on busbars with sizes 10x80. It's because after discussion with the production manager, a product in this size is the product most often produced by PT. XYZ. So that products in this size are a priority that needs more attention to reduce losses.

Defective products can cause waste [1], [2]. According to [3]–[5] quality control is closely related to the efficiency of production costs, the effectiveness of achieving production targets, and increasing production productivity and will have a significant impact on the company's success. By undergoing quality control, it is expected that the reduction of production costs and increased productivity of the company can run smoothly. This research is carried out by analyzing the types of busbar defects that occur and the total of busbar production defect. The most dominant type of reject is prioritized because it is the factors that causes the highest loss among other types of reject type. To research the improvement of busbar quality by knowing the causes and solutions to reduce the defects in busbar products at PT. XYZ, the researcher uses six-sigma method. Six sigma method is one of the method that can be used to analyze the causes and solution to reduce defects [6]–[8]. From this method, the sigma level of the defect will be obtained. Researcher can also determine the factors causing the occurrence of defective products and formulate recommendations for quality improvement with all the types of defects. The recommendations given are expected to reduce the number of defective products that will be produced in the future.

2. Methodology

Quality control is an activity carried out to minimize possible defective products going well in maintaining product quality and services according to market needs. The main objective of quality control is to obtain quality assurance that the products or services produced are following the established quality standards at an economical or minimal cost.

Six sigma where six means six and sigma which means a symbol that can be interpreted as a measure and statistical unit which symbolizes the ability of a process and the size of a sigma value. Six sigma is a process that can be associated with a performance in which performance must be improved in the company. Performance can be improved by monitoring business activities to reduce disability. This is done to achieve customer satisfaction. Six sigma aims to almost perfectly meet customer requirements. Six-sigma is a vision of quality improvement towards a target of 3.4 failures per million opportunities for every transaction of goods and services. So, six sigma is a method or technique of controlling and improving dramatic quality which is a breakthrough in the field of quality management. Customers will feel satisfied when they receive the value they expect. When a product is processed at the Six Sigma quality level, then the company may expect 3.4 failures per million opportunities or expect that 99.99966 percent of what customers expect will be in the product. The Six-sigma concept is to be defined in the manufacturing field; six aspects need to be considered :

1. Identify product characteristics that satisfy customers (according to customer needs and expectations).
2. Classify all the quality characteristics as individual CTQ (Critical-To-Quality)
3. Determine whether each CTQ can be controlled through material control, work process machines, and others.

4. Determine the maximum tolerance limit for each CTQ as desired by the customer (determine the UCL and LCL values of each CTQ).
5. Determine the maximum process variation for each CTQ (determine the maximum standard deviation value for each CTQ).
6. Change the product and / or process design in such a way as to achieve the Six Sigma target values.

Six aspects need to be considered in the application of the six-sigma concept, such as customer identification, product identification, identification of needs in producing products for customers, process definition, avoiding errors in the process 12 and eliminating all existing waste, the process level continuously towards the six-sigma target. Product Quality Control Using a Six Sigma Approach. The method used refers to the principles contained in the Six Sigma method. This method is used to anticipate errors or defects by using measurable and structured steps. Based on existing data, continuous improvement can be done based on the Six Sigma methodology which includes DMAIC.

1. *Define*
   Define is the goal setting of Six Sigma quality control activities. This step is used to determine the action plan that must be taken to carry out the improvement of each stage of the business process . The step from define is to set goals for the six-sigma quality improvement activity. At the top management level, the goals set will become the strategic objectives of the organization such as increased return on investment 13 (ROI) and market share. At the operational level, the objectives might be to increase production output, productivity, reduce defective products, and operational costs. At the project level, the goals can also be similar to the operational level, such as: lowering the defect rate, reducing machine downtime, increasing the output of each production process.

2. *Measure*
   Measure is a logical follow-up to the define step and is a bridge to the next step. Measure steps have two main objectives, namely :
   a. Obtain data to validate and qualify problems and opportunities. Usually, this is critical information for revising and completing the first project charter.
   b. Get started with touching facts and figures that provide clues about the root of the problem.

3. *Analyze*
   This is the third operational step in the Six Sigma quality improvement program. There are several things that must be done at this stage, namely :
   a. Determine the stability and capability (capability) of the process.
   b. Establish performance targets for the key quality characteristics (CTQ) Conceptually setting performance targets in a Six-Sigma quality improvement project is very important.
   c. Identify the sources and root causes of quality problems. To identify the problem and find the source of the quality problem, a causal diagram or fishbone diagram analysis tool is used. This diagram shapes ways of making better products and achieving their results (results).

4. *Improve*
   In this step, an action plan is implemented to implement Six Sigma quality improvement. The plan describes the allocation of resources and priorities or alternatives to be carried out. The Six Sigma quality improvement team must decide 17 on the targets that must be achieved, why the action plan is carried out, where the action plan will be carried out when the plan will be carried out, who is responsible for the action plan, how to implement the action plan and how much will the implementation cost and positive benefits of implementing that action plan. The Sigma projection team has identified the sources and root causes of quality problems as well as monitoring the effectiveness of action plans that will be implemented over time.

   The effectiveness of the action plan taken will be seen from the decrease in the percentage of quality failure costs (COPQ) to the total sales value as Sigma's capabilities

increase. Every action plan that is implemented should be evaluated for its effectiveness through achieving performance targets in the Six Sigma quality improvement program, namely reducing DPMO to zero failure targets (zero defect oriented) or achieving process capabilities at a level greater than or equal to 6- Sigma, and converting benefits. results in a reduction in the percentage cost of quality failure (COPQ).

5. *Control*
   Control is the last operational stage to improve quality based on Six Sigma. At this stage the results of quality improvement are documented and disseminated, successful best practices in process improvement are standardized and disseminated, procedures are documented and used as standard guidelines, and ownership or responsibility is transferred from the team to the owner or person in charge of the process.

3. Result and Discussion

The primary data collected in this study is a description of the production process that occurs in the busbar production than we can see in define stage and data on the reject problems that occur in the busbar size 10 x 80 cm at PT. XYZ. The defect types of busbar size 10 x 80 cm that produce by PT. XYZ are Bent busbar, Scratched Visual, Oxidized Visual, Crack Visual During Bending Test. This primary data was obtained through a process of field research and interviews with Mr. X as the copper production manager at PT. XYZ. The interview in collecting primary data was conducted in November 2020. Secondary data is data obtained indirectly from data sources but from other available sources. Existing data is then processed according to the calculations to be carried out. Primary data collected in this research is the production process and the types of defects found in the production of the busbar 10 x 80 cm at PT. XYZ. Then the secondary data collected in the data processing process is the total production data and the total reject busbar size 10 x 80 cm. The data on total production and total rejects used are data that occurred for 21 months starting from January 2019 - September 2020 which occurred in the production process.

a. *Define*

The define stage is the first step by using the six-sigma method. At the define stage, the steps taken are defining the problems that occur at PT. XYZ and determination of goals to be achieved. The define stage in this research identifies the production process, defective products and determines the characteristics of Critical to Quality (CTQ) and determine SIPOC diagram. The define stage can be seen at the points below. At this stage, a definition of the busbar production process at PT. XYZ is carried out which will determine the types of defects that occur in the busbar and the best improvement for reduce the defect total. The process of making a busbar is done using 3 machines. CTQ is an important- attributes to pay attention to because they are directly related to customer needs and satisfaction. CTQ is an element of a product, process, or other specification that is directly related to customer satisfaction. Before measuring the CTQ, it is necessary to evaluate the existing measurement system to ensure its effectiveness over time [10]. After conducting research in the field and conducting interviews with the production manager, the determining factors for the quality of the busbar are that the busbar is not bent, the busbar is not scratched, the busbar is not oxidized and the busbar is not cracked and has a strong material. The calculation of the Pareto diagram uses the frequency data of all types of defects generated for 21 months. The calculation that done in the Pareto diagram is determining the percentage value of defects and the cumulative value of defects of all types of defects that exist. The results obtained in this step are determining the types of defects that are the top priority for repairs.

b. *Measure*

The measure stage is the second phase of the DMAIC process stage. This stage aims to measure the performance of the identification results that have been made at the define stage. At this stage the performance measurement is carried out on the reject busbar product size 10 x 80 cm which occurs in the production process 44 at PT. XYZ. At the measure stage, the process carried out is the calculation of DPMO (Defect Per Million Opportunities), the calculation of the company's sigma value, and the calculation of the p control map for reject products.

c. *Analyze*

Analyze is the stage of identifying the factors that cause problems that have been determined from the previous stages. Analyze stages are carried out by determining the root cause of the type of defect using the fishbone diagram method and determining the cause of product defect based on the highest Risk Priority Number (RPN) value of each type of defect using the Failure Mode and Effects Analysis (FMEA) approach. Identification of problem factors is carried out on the selected types of defects based on Critical to Quality (CTQ), namely scratched visuals and bent busbar.

d. *Improve*

The improve stage is the fourth step in the quality improvement program using the six-sigma method. This step is carried out after identifying the source and root causes of quality problems in the company. The improve phase is in the form of proposed corrective actions to problems that occur with the aim of improving quality. The improvement suggestion in this research is based on the causes of the failure modes that have been made from the results of FMEA analysis at the Analyze stage.

Visual scratched caused on the draw bench machine. The input that will enter the machine and pass through the dies (mold) will be sprayed first using a lubricant liquid. This function is to smooth the busbar when it is inside the dies and make the busbar not hot when inside the dies. The problem that occurs with the lubricant fluid is that it is contaminated with scrap. The lubricant liquid that is sprayed into the busbar will be flowed back to the place where the liquid is stored. So that the liquid cycle will continue to rotate. The place for storing lubricant fluids is right under the draw bench machine in the busbar molding section with dies. This causes the busbar scrap produced during the molding process to fall down and enter the liquid. So that the lubricant fluid is contaminated with scrap. When the lubricant fluid is dirty and contaminated in the scrap, when the liquid is sprayed onto the busbar scrap it can cause visual strarched on the busbar. The fluid is replaced once a week.

The occurrence of bent busbar is caused in the production process on the drawbench machine. In the drawbench machine, the moulding, straightening and cutting of the busbar are carried out. PT. XYZ has not set a standard for the strength of straightening the busbar. The strength is set according to the size of the busbar to be produced. Because the less strength the machine straightening the busbar, the busbar will not be visually straight. The busbar will tend to be bent. So far, the operator has only done trial and error setting the strength of the draw bench machine in pulling the busbar until the product is produced according to demand. this causes the waste of busbars. The proposed improvement for this type of defect is making the instruction work of drawbench machine.

4. Conclusion

The results of problem identification show that there are four types of defects in the production process that cause malfunction in the 10 x 80 cm busbar product, namely bent busbar, scratched

visual, oxidized visual, cracked visual during bending test. Based on the calculation, obtained two Critical to Quality (CTQ) of the four quality characteristics, namely bent busbar and scratched visual which are used as research objects. The product quality for the 10 x 80 cm busbar produced by PT. XYZ still needs to be improved. This can be seen from the sigma level value obtained by the company from the calculation, which is 3.607. Proposals for priority improvements to the quality of 10 x 80 cm busbar products that can be made by PT. XYZ Improvement of Scratched Visual: Proposing filter installation and filter replacement once a month and proposing to check the lubricant water before doing the production process in work instruction. Improvement of Scratched Visual: Proposing Work Instruction of drawbench machine for bent busbar repair.

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