WIRE ROD QUALITY IMPROVEMENT USING PDCA IMPLEMENTATION AT PT. XYZ

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ABSTRACT

PT. XYZ is a company engaged in the automotive sector that produces wire rods with a drawing process. However, in the process of making a product, it does not always get results that are in accordance with the standards. The problem that arises in the manufacture of wire rods is that the surface of the wire rod becomes rough after going through the forging process at the customer. This problem got some of the root of the problem but most likely caused by mechanical properties. Quality control must be carried out to deal with these problems through a continuous and continuous process. One of the ways to control the quality is through the implementation of PDCA (plan – do – check – action). From the results of trials carried out by implementing PDCA for repair of wire rods that experience NG or roughness in the product after the forging process. Then it is known that the root cause of NG is influenced by mechanical properties. Then an experiment was carried out by changing the radius of the dies from the previous one using R20 to R12, then a tensile test and a hardness test were carried out on the material. And get the result that by using R12, the surface hardness of the material is better than R20. After knowing this, a trial was carried out on 30 materials using a radius of R12 dies and got results with a surface hardness level that was above the standard to be determined. Then the last step is to standardize the changes.

Keywords: PDCA, Quality Control, Tensile Test, Hardness Test, Wire Rod

I. INTRODUCTION

PT. XYZ is a company engaged in the automotive sector that produces wire rods with a drawing process. However, in the process of making a product, it does not always get results that are in accordance with the standards due to various aspects that have not been able to meet quality standards. There are various types of materials and specifications requested by the customer which causes the manufacturing process of a material to be different in producing good quality and according to demand. Based on this, a problem arises in the wire rod manufacturing process which causes the wire rod surface to become rough after going through the forging process at the customer. Based on this problem, several root causes were found, but the most likely caused by mechanical properties as shown in Figure 1.

Figure 1. Fishbone Diagram of Rough Product Surface
Based on shipping data from October to November, of the total 48 tons of wire rods that have been sent to customers, 12.5% of the total shipped or about 6 tons of wire rods were identified as NG products. The material is identified as a NG product because each roll that has been processed through the forging process always produces NG products, so the 6 wire rod coils are identified as NG products. Based on these problems, the company needs to make improvements to improve quality so that it can suppress NG products from the forging process.

Quality control must be carried out through a continuous and continuous process. One of the ways to control the quality is through the implementation of PDCA (plan – do – check – action) which was introduced by Dr. W. Edwards Deming a renowned quality expert from the United States, so this cycle is called the Deming Cycle (Deming Cycle / Deming Wheel). PDCA is very suitable to be used for small-scale continuous improvement activities to shorten work cycles, eliminate waste in the workplace and productivity. (Dewi, N, & Listyorini, 2013)

The PDCA cycle is generally used to test and implement changes to improve the future performance of a product, process or system. (Bastuti, 2017).

II. STUDY LITERATURE

The experimental research method is a quantitative research method used to determine the effect of the independent variable (treatment) on the dependent variable (outcome) under controlled conditions. Conditions are controlled so that no other variables (other than the treatment variable) affect the dependent variable. In order for conditions to be controlled, experimental research uses a control group. (Rakhmat J., 1990) The control group used in this material is the Plan Do Check Action (PDCA) method.

The Plan Do Check Action (PDCA) method was introduced by Dr. W. Edwards Deming (Deming, 1982) and often also called the Deming Cycle (Deming Cycle). The PDCA method is an improvement process that is continuously improved. This process is carried out linearly, with the completion of the cycle associated with the start of the next cycle. The PDCA cycle is typically used to test and implement changes to improve the performance of a product, process, or system that have an impact on future success. (Kurniawan & Azwir, 2018)

Gambar 2. PDCA Cycle

The following are the stages of the PDCA cycle in Figure 2 which are explained as follows:

a. Developing a plan (Plan) is planning the details and setting good process standards.
b. Implementing the plan (Do) is implementing the plans that have been put forward at the planning stage and implemented in stages, as well as making improvements as well as possible so that the planned targets are achieved.
c. Checking the results achieved (Check) is checking the results of improvements with predetermined targets. If the target has been achieved, the process stage can be continued in the next stage, namely the Action stage. If the process does not meet the desired target, the process is rolled back at the planning stage to re-plan the activities that must be carried out to achieve the specified target.
d. Taking action is making adjustments to a process if necessary based on the results of the analysis that has been carried out in the previous stages. This adjustment was made in order to prevent the recurrence of the resolved problem. And put forward what problems will be done after fixing the problems in the previous problem is resolved. (Momon, 2012)
To increase productivity, improvement steps that can be taken are to apply the seven tools PDCA (Plan-Do-Check-Action) method. This method can be used to determine where improvements must be made and how the corrective steps are taken, to obtain a new standard in standard operating procedures (SOP). The application of the PDCA seven tools method is expected to improve product quality (Rasidagic & Hesova, 2020; Paul & Mukkadan, 2020; Dollete, 2020).

Seven tools are seven kinds of statistical tools used to identify and analyze the root causes of problems related to quality control in production. The seven tools method consists of seven control tools consisting of a check sheet, histogram, scatter diagram, stratification, Pareto diagram, control chart, and fishbone. (Hardono, Pratama, H, & Friyatna, A., 2019)

The tests carried out in this study used seven Pareto diagram tools and Chart Control. A control chart is a chart or map with boundaries and these lines are called control lines. There are three kinds of control lines, namely: upper control limit, center line and lower control limit which can be illustrated in Figure 3. The control lines are written as UCL, x bar, and LCL in the same order. (Nasution, 2006).

Attribute Control Chart or Attribute Control Map is suitable for controlling the process by using Attribute Data, one example is the number of units that fail to produce (Reject). The type of control chart that serves to measure the proportion of defective (failure/defect) in production is the p-chart. (Khikmawati, 2018) Attribute control charts are used to control product quality during the production process which cannot be measured but can be calculated, so that product quality can be distinguished in terms of good or bad characteristics, success or failure. Damage control chart (p-chart) is used to analyze the number of rejected items found during inspection or a series of inspections of the total items inspected. (Montgomery, 2001)

Pareto chart is a graph that shows a problem in order of number of occurrences. The problems that occur the most are shown by the first highest bar graph and are placed on the far left and so on until the problems that occur the least are shown by the last, lowest bar graph and are placed on the far right. (Besterfield, 2009)

The seven tools method is a statistical process control used in this study to test product quality. (Yamit, 2010) This study will conduct product quality testing where the tests carried out are tensile strength tests, hardness tests, and wire pulling tests. Tensile testing is one of the most common material tests carried out in the industrial world because this test is considered the easiest and a lot of data is obtained from this test. The data that can be obtained from the tensile test are Ultimate Tensile Strength, Yield Strength or Yield Point, Elongation, Elasticity and Reduction of Area. The parameter of tensile test shown in Figure 4 below.

![Figure 3. Control Chart Graphic](image)

![Figure 4. Tensile Test Strain Curve](image)
Tensile test curve can be obtained from several mechanical properties of the material. Some of the mechanical properties of the material in question are from tensile strength, ductility, and elasticity. (Budiman H., 2016)

The hardness of a material is defined as a test to determine the resistance of a material to the penetration of other materials on its surface and in the face of deformation. There are three types of hardness measures, depending on how the test is performed. (E143-02(08), 2013) The three types are Scratch hardness, Indentation hardness, and rebound hardness. (Nugroho, 2018) However, the easiest and most commonly used test method is emphasis-based testing. Hardness testing is divided into three methods, namely the Rockwell method, the Brinell method and the Vickers method. The Rockwell method is determined based on the depth of the indenter to the specimen, while Brinell and Vickers focus on the relationship between the strength of the material and the cross-sectional area. (E143-02(08), 2013)

The definition of wire drawing or drawing is the process of reducing the diameter of the rod or wire by applying a tensile force through a number of dies which forces the wire to be smaller as shown in Figure 5. (Wijaya, 2017)

![Figure 5. Drawing Process](image)

From several tests carried out on the material, to be able to find out the cause of a material experiencing a discrepancy, it is necessary to use the experimental method. Where the experimental method aims to examine the causal relationship by manipulating one or more variables in one or more experimental groups and comparing the results with the control group that did not experience manipulation. (Rakhmat, 2019)

III. METHODOLOGY

The steps of this research are shown in Figure 5. The research began by conducting field studies and collecting data, namely, sample part rejects, production process data, types of defects, and factors causing defects. This research is continued with the application of the PDCA concept to repair defects that occur in the product, namely: the Planning stage (Plan) which consists of problems and sets targets for what must be done to achieve improvements. Implementation stage (Do) which consists of hardness test, tensile test, and checking of structural materials. Next is the Evaluation Stage (Check), this stage consists of evaluating the results of improvements using a control chart. If the evaluation results have reached the target, then standardized so that the process and quality obtained are maintained, then proceed to the next stage, namely the Standardization Stage (Action). The results of the application of the PDCA concept were analyzed to draw conclusions from this study.
IV. RESULTS

From the observations of 6 materials that had problems with the customer, 2 samples of the NG part were taken after the forging process which was rough on the surface, which caused the product not to comply with quality standards as shown in Figure 6.

Figure 6. Part NG sample after after forging

From a total of 48 rolls of wire rod materials that were sent, there were 6 rolls identified as NG found on the customer. Here are some possibilities that cause these 6 materials to have problems, as shown in Figure 7.

Figure 7. Pareto Chart Rough Product Surface

Based on the Pareto diagram in Figure 7, it is known that the main cause that causes roughness on the surface of the product after the forging process is the mechanical properties.
Stages of Planning (Plan)

The plan that will be made to solve the problems that are happening to the customer is to do a trial using the experimental method by changing the dies angle from R20 to R12 which aims to increase the level of surface hardness of the material so that the expected result is to minimize the occurrence of rough product surfaces at the time after the forging process, the sample to be tested using dies with R12 as much as 2 tons / 2 wire rods, after that, a control of 30 wire rods will be carried out as shown in Figure 8.

![Figure 8. Shape Radius Dies](image)

Implementation Stages (Do)

The next step of the planning that has been made is to carry out the experimental method. By taking 2 samples from the drawing process for tensile and hardness tests.

Tensile Test

This test uses an Amsler machine which is used to test the material to determine the tensile strength and elongation strength of the material. The following are the results obtained in the tensile test as shown in Table 1.

<table>
<thead>
<tr>
<th>Point Check</th>
<th>Std</th>
<th>Tensile Test Results</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>R20 (Before Improvement)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>sample 1</td>
</tr>
<tr>
<td>Tensile Strength (TS)</td>
<td>314 - 392 Mpa</td>
<td>367</td>
</tr>
<tr>
<td>Yield Point (YP)</td>
<td>-</td>
<td>333</td>
</tr>
<tr>
<td>Elongation (El)</td>
<td>≥ 35%</td>
<td>44.1</td>
</tr>
<tr>
<td>Reduce Area (Ra)</td>
<td>≥ 70%</td>
<td>74.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>R12 (After Improvement)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>sample 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>350</td>
</tr>
<tr>
<td></td>
<td></td>
<td>308</td>
</tr>
<tr>
<td></td>
<td></td>
<td>45.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>73.2</td>
</tr>
</tbody>
</table>

Hardness Test (HRB)

In the hardness test there are 2 check points that need to be known including HRB and Surface Hardness. The following image as shown in Figure 9 are the checking points in the hardness test:
Table 2. Hardness Test Table

<table>
<thead>
<tr>
<th>Point Check</th>
<th>Std</th>
<th>Violence Result</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>R20 (Before Improvement)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>sample 1</td>
</tr>
<tr>
<td>HRB</td>
<td>≤ 73</td>
<td>63.6</td>
</tr>
<tr>
<td>Surface Hardness</td>
<td></td>
<td>64.9</td>
</tr>
</tbody>
</table>

From the data obtained for standard surface hardness on Table 2, the lower limit must be limited to avoid roughness, because from the data obtained the NG sample for surface hardness below 65 is not good.

**Stages of Evaluation (Check)**

Evaluation activities were carried out after the experimental process using 2 samples was completed and received information from the customer regarding the 2 wire rod samples. After that, 30 wire rods (N30) will be controlled. Then the following results are obtained:

![Figure 9. Point Check Violence](image)

![Figure 10. Control Map of Experimental Results After Repair](image)
Based on the experimental control map shown in Figure 10, it was found that by lowering the radius of the dies used to R12, it would increase the level of hardness

**Standardization Stage (Action)**

Standardization is a treatment or prevention effort for the same problem to arise in the future, with experiments carried out and several analyzes concluded, the following is the standardization carried out on the repair activities that have been carried out:

1. Making dies
2. Make WI by changing the radius of Dies
4. Disseminate to the relevant team

From the results of trials carried out by implementing PDCA for repair of wire rods that experience NG or roughness in the product after the forging process. Then it is known that the root cause of the occurrence of NG is influenced by mechanical properties. Then an experiment was carried out by changing the radius of the dies from the previous one using R20 to R12, then doing a tensile test and testing the level of hardness of the material. And get the result that by using R12, the surface hardness of the material is better than R20. After knowing this, a trial was carried out on 30 materials using a radius of R12 dies and got results with a surface hardness level that was above the standard to be determined. Then the last step is to standardize the changes.

**REFERENCES**