Quality Control Analysis Using Six Sigma Method to Reduce Post Pin Isolator Reject in Natural Drying Pt Xyz

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Abstract: This study aims to analyze the product failure of the type of pin post insulator product, as well as to find the main cause and to propose improvements at PT XYZ using the Six Sigma method. This research was conducted only in parts of the production process that have a high failure rate such as in natural drying sections. This study uses a Six Sigma methodology approach with tools such as Fishbone diagrams and Pareto diagrams. This research is a quantitative descriptive exploratory method. The results of this study were the type of cracked lip crack caused by the vacuum is unstable in finishing section, with the improvement of cleaning the vacuum duct and routine maintenance vacuum duct in finishing machine. For the type of cracked middle skirt crack caused by the auger on pugmill machine being worn, between the dimensions of Honggote (HG) in the forming and Sita in finishing are not matching, with corrective actions: repairing pugmill machine, vacuum duct in finishing section, repairing sita so that HG and sita are matched and conducting routine test and periodic maintenance. The conclusion of this research is that quality control using the six sigma method can reduce the rejection level and increase the six sigma level.

Keywords: Six Sigma, Quality Improvement, Fishbone Diagram, and Ceramic Insulator.

I. INTRODUCTION

This company is one of the industries in the industrial sector in the field of medium voltage ceramic insulators, namely the production of 22 kV pin post insulators. In April 2020, the company had a Pin Post production failure in the sections natural drying is 2.49% and the company also targets a reject level for the natural drying at 0.5%. Thus it is necessary to control product quality to achieve production defect targets.

Researchers chose quality control using Six Sigma because "Six Sigma is a new management tool used to improve Total Quality Management, very focused on quality control by exploring the company's overall production system which aims to eliminate production defects" (SHIFT Indonesia, 2017). Six Sigma is considered better than other methods such as Total Quality Management (TQM), TQM is a method for implementing and managing overall quality improvement activities in an organization (Usman).

Many researchers have previously researched quality control using the Six Sigma (DMAIC) method in various industries but only a few have researched quality control using the Six Sigma method in the ceramic insulator industry. Previous researchers explained the application of Six Sigma in the water industry (Didiharyono, Marsal&Bakhtiar, 2018), the application of six sigma in the electronics goods industry, namely the Blue-Ray Disc Player (DonyAriefWidiatmoko), the application of six sigma in the car painting industry (Mohamed A Rahman, AKM Mohiuddin&Hanani Abdullah, 2015), the application of six sigma in the construction industry (Molly Thomas &I.Porcia, 2017).

This study will analyze any failures in the production section of pin post ceramic insulators, as well as find the main causes of the failure of the product and provide suggestions for its repair. This research is also to determine the value of SQL (Sigma Quality Level) in the production natural drying section of pin post ceramic insulators.

II. THEORETICAL REVIEW

A. Control

Control is a process by which managers monitor and regulate how an organization and all its members carry out the activities needed to achieve organizational goals efficiently and effectively (Jones and George, 2003).

B. Quality

Juran (1995) defines three qualities that are used, namely:
1. Quality is the specialty of a product that answers consumer needs.
2. Quality is free from defects
3. Quality is compatibility with the intended use.
C. Defect

Good quality according to the manufacturer is if the product produced by the company is in accordance with the specifications determined by the company, while bad quality is if the product produced does not comply with the predetermined standard specifications and results in a damaged product (Wahyu, 2009).

D. Six Sigma-Introduction and overview

At the end of 1970, Dr. Mikel Harry, a senior engineer at Motorola's Government Electronics Group, started an experiment to solve the problem using statistical analysis. Using Motorola's GEG is starting to show dramatic improvements: products are designed and produced faster at less cost. He then wrote this method in a paper entitled "The Strategic Vision for Accelerating Six Sigma Within Motorola", Dr. Mike Harry was then assisted by Richard Schroeder, a former Motorola executive, to develop a data-driven change management concept. The result of this collaboration is a simple quality measurement tool, which later became a philosophy of business progress, known as Six Sigma.

Six sigma is a management tool used to replace Total Quality Management (TQM) which is very focused on quality control by exploring the company's overall production system (AchmadSutawijaya & Lenny Nawangsari, 2019). The six sigma method has been widely applied in order to improve performance, such as the manufacturing industry (Linderman, et al., 2003), health and safety (Rimantho & Cahyadi, 2016; Sanjit, et al., 2011), environmental management systems (Calia, et al., 2009).

III. METHODOLOGY

The research methodology used in this research is a case study research with the aim of describing the application of Six Sigma to the ceramic manufacturing industry in natural drying section. This study uses primary data, namely data that is directly obtained and collected in the research area, such as: the condition of the materials used, work instructions and data of employees who work in the production department, while secondary data is data obtained from indirect sources that have been previously made. and used for research processes such as: process flow data and employee competency matrices.

Data collection techniques using interviews with several employees in the drying section of nature, observation (direct observation) and documentation. The samples in this study were all internal reports on the production section of ceramic insulator pin post in the natural drying section. In analyzing and calculating data using the six sigma calculator and the minitab18 application.

IV. RESEARCH RESULTS

There are five stages of DMAIC as a characteristic of Six Sigma, and these five phases have been implemented by the Motorola company (George, et al., 2004), including:

1. Define Phase

The purpose of this step is to clearly define the problem and what the impact of the problem is on customer satisfaction, stakeholders, employees and organizational probability.

a. Process Flow

Figure 1 shows a production process flow diagram, namely a diagram showing the general flow of the process and equipment of a pin post ceramic insulator plant.

b. SIPOC Diagram

Figure 2 shows a diagram of SIPOC (Supplier, Input, Process, Output and Customer), which is a tool for identifying the flow of raw materials, machinery, production processes, finished product output until the receipt of goods by the customer for the natural drying section.

c. Critical to Quality (CTQ)

Critical To Quality (CTQ), namely the requirements of QC to achieve customer satisfaction so that there are no complaints from the previous process. Table 1 shows the Critical to Quality (CTQ) production of pin post ceramic insulators in the natural drying section. Table 2 and Figure 3 show the definition of the defect type of the product.

d. Identification of Problems

In data collection and problem identification, data was obtained in April 2020, there were products that failed in the production of pin post in some parts of natural drying by 2.49% and the company targeted a rejuvenation level value of 0.5%. Thus it is necessary to control the quality of production so that the level of production defects can meet the target value of rejection.
Fig 1: Process Flow of Making Ceramic Pin Post Insulator

Fig 2: SIPOC diagram produces Pin Post ceramic insulator in Natural Drying section

Table 1: CTQ natural drying section

<table>
<thead>
<tr>
<th>Quality characteristics</th>
<th>Performance Requirement</th>
<th>Type of defect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compatibility of visual conditions</td>
<td>Nothing cracked</td>
<td>RA, RRT, RBR, RL1, RL2, RD1, RD2, RRA</td>
</tr>
</tbody>
</table>

Table 2: Defect Definition Table
<table>
<thead>
<tr>
<th>No</th>
<th>Code</th>
<th>Name Reject</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Form</td>
<td>Reject form forming</td>
<td>The flak from forming because the shape does not match the image on the leg (tilted leg / dent)</td>
</tr>
<tr>
<td>2</td>
<td>Slip</td>
<td>Slip</td>
<td>When it is formed by the finishing machine, the finishing knife stops halfway when it forms.</td>
</tr>
<tr>
<td>3</td>
<td>RA</td>
<td>Cracked Head</td>
<td>Cracks at the edge of the upper leaf for the marking part of the pin post</td>
</tr>
<tr>
<td>4</td>
<td>RBR</td>
<td>Cracked Lip Skirt</td>
<td>The crack in the middle arch in the skirt from the pin post</td>
</tr>
<tr>
<td>5</td>
<td>RRT</td>
<td>Crack Middle Skirt</td>
<td>The crack in the center of the radius in the skirt.</td>
</tr>
<tr>
<td>6</td>
<td>RRA</td>
<td>Top Radius Crack</td>
<td>The crack in the first neck from the top of the pin post</td>
</tr>
<tr>
<td>7</td>
<td>RK</td>
<td>Cracked Legs</td>
<td>Crack the base of the leg of the pin post</td>
</tr>
<tr>
<td>8</td>
<td>RD1</td>
<td>1st Leaf Crack</td>
<td>That is, the cracked edge of the first leaf</td>
</tr>
<tr>
<td>9</td>
<td>RD2</td>
<td>2nd Leaf Crack</td>
<td>Namely the crack at the edge of the second leaf</td>
</tr>
<tr>
<td>10</td>
<td>RL1</td>
<td>1st Neck Crack</td>
<td>The crack in the first neck from the top of the pin post</td>
</tr>
<tr>
<td>11</td>
<td>RL2</td>
<td>2nd Neck Crack</td>
<td>The crack in the second neck from the top of the pin post</td>
</tr>
<tr>
<td>12</td>
<td>PB</td>
<td>Broken Body</td>
<td>That is, the pin post is split in two, between the leg and the body or between the first neck and the second neck with the feet</td>
</tr>
<tr>
<td>13</td>
<td>RDR</td>
<td>Crack In Skirt</td>
<td>Cracks in the radius in the skirt, into the body (sideways and not in the middle of the radius)</td>
</tr>
<tr>
<td>14</td>
<td>LM</td>
<td>Laminate</td>
<td>Cracks in the body of the pin post. The fractions looked twisted</td>
</tr>
<tr>
<td>15</td>
<td>SOMPEL</td>
<td>Sompel</td>
<td>That is a small fraction in a certain part of the pin post</td>
</tr>
<tr>
<td>16</td>
<td>PUNTIRAN</td>
<td>Twist</td>
<td>The twisted fracture of the leg due to the forming / pugmill</td>
</tr>
<tr>
<td>17</td>
<td>TB</td>
<td>Paste Material</td>
<td>The remaining material that sticks during the forming process (usually attached to the inside of the pin post skirt)</td>
</tr>
<tr>
<td>18</td>
<td>PK</td>
<td>Broken leg</td>
<td>The pinpost leg was broken with the body and skirt</td>
</tr>
<tr>
<td>19</td>
<td>PL1</td>
<td>1st neck fracture</td>
<td>Fracture of the first neck from above the pin post as a result of mechanical stress</td>
</tr>
<tr>
<td>20</td>
<td>PL2</td>
<td>2nd neck fracture</td>
<td>Fracture in the second neck from the top of the pin post as a result of mechanical stress</td>
</tr>
</tbody>
</table>
| 21 | C.GLZ | | Spot without glaze or insert small objects on the glaze layer and small holes. Where the provision is that the total glaze defect area in each insulator unit must not exceed: 

\[
100 \times \frac{D \times F}{20000} \text{ mm}^2
\]

And every single glaze defect must not exceed:

\[
50 \times \frac{D \times F}{20000} \text{ mm}^2
\]

D = largest diameter of the insulator
F = The creepage distance of the insulator

So for pin posts, the total glaze defects must not exceed:

\[
100 \times 170 \times 534/20000 = 4539 \text{ mm}^2
\]

And every single glaze defect must not exceed:

\[
50 \times 170 \times 534 / 20000 = 226.95 \text{ mm}^2.
\]

(Source: Data processing company, 2020)
Table 3: Production data of pin post insulators in April 2020

<table>
<thead>
<tr>
<th>Bagian Proses</th>
<th>Total produksi</th>
<th>Rijek</th>
<th>% Rijek</th>
<th>Target Rijek</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural Drying</td>
<td>21.556</td>
<td>532</td>
<td>2.47</td>
<td>0.50%</td>
</tr>
</tbody>
</table>

(Source: Data processing company, 2020)

2. Measure Phase

The measure phase consists of finding and executing the data that has been collected to establish the basics of improvement and measuring the CTQ as the target process and calculating the sigma level value.

a. Production Control Chart

To create a control chart and binomial capabilities of each production section, researchers used the help of the Minitab 18 application. Figure 4: shows the control chart and capabilities in the finishing, natural drying, oiling, combustion and routine test sections.

b. Calculating the Sigma Level

In calculating the value of DPO and DPMO using historical data for April 2020, which shows the capability of the process before repair. Measurement of the six sigma level with the help of the six sigma calculator application. Table 6 shows the results of the calculation of DPO, DPMO and six sigma level.

Table 6: The six sigma calculation results table

<table>
<thead>
<tr>
<th>Proses</th>
<th>DPO</th>
<th>DPMO</th>
<th>Level Sigma</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural Drying</td>
<td>0.024679904</td>
<td>24679.904</td>
<td>3.47</td>
</tr>
</tbody>
</table>

(Source: Data processing company, 2020)
3. Analyze Phase

Analyze phase is the stage of isolating the main cause of the focused CTQ, therefore determining the root of the problem using the Pareto diagram and the source of the cause of the defect using a fishbone diagram.

a. Pareto Diagram

Figure 4 shows the Pareto diagram of the natural drying section. From the figure, it can be seen that the main failure is RBR (Cracked Skirt Lip).

(From: Data processing company, 2020)

Fig 4: Pareto diagram parts of natural drying section.

b. Fishbone Diagram

To find the main causes of product failure, direct interviews were conducted with sources who were considered to be experts, then a Fishbone Diagram was made. Brainstorming was conducted to determine the possible root causes from the fishbone diagram. The figure in appendix 1 shows a fishbone diagram of a natural drying section.

4. Improve Phase

Analyzing the problem and taking corrective action to reduce pin post insulators using 5W1H tools (Why, When, Who, Where, What and How). Table 6 shows the 5W1H table.

5. Control Phase

In the Control stage, the selected solution is implemented, with the aim of controlling the process whose performance has been improved and maintaining that performance. Table 7 shows the control measures to maintain the changes made in the improve phase.

a. Analysis capabilities

Comparison of process performance after repair with specified requirements and before repair can be seen in Appendix 2.

b. Calculates the six sigma level

Calculation of the six sigma level is done again to determine the achievement of the six sigma level and improvement is carried out again. Table 7 shows the results of the calculation of the six sigma level after the improve stage.

From the table, it is found that the results of the improvements that have been made can reduce the DPMO value, in the natural drying section from 24679.9 to 3800.6. Meanwhile, there was an increase in the sigma value, in the natural drying section from 3.47 to 4.17.

V. CONCLUSIONS AND SUGGESTIONS

A. Conclusions

Based on the results of the research that has been done, it can be concluded that:

In the finishing part, rijek occurs: RRT (middle skirt crack) and RBR (skirt lip crack), caused by: the pugmill machine is worn out, Vacuum in the finishing section is unstable and the Honggote (HG) radius in the forming section does not match the Sita radius in the finishing section. The corrective actions are as follows: cleaning the vacuum lines in the finishing section and keeping them clean from material dirt, repairing the auger by patching the worn auger and periodic maintenance and repairing Sita in the finishing section so that the radius matches the HG in the forming section.

The use of the Six Sigma method has a positive effect on the quality of the products produced. This is indicated by increasing the six sigma level from 3.47 to 4.17.

B. Suggestions

There are several suggestions that can be put forward in this research and are likely to have an impact on both the company and the industrial world, including:

- Suggestions for companies to continue research to achieve a higher level of six sigma or zero defects by increasing employee competence in implementing Six Sigma.
- The need for further research into departments other than production for continuous improvement.
Table 6: Tabel 5W1H

<table>
<thead>
<tr>
<th>No</th>
<th>Penyebab</th>
<th>Why</th>
<th>What</th>
<th>Where</th>
<th>When</th>
<th>Who</th>
<th>How</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Vacuum in the finishing part is not stable (too big or small)</td>
<td>Because the vacuum duct is clogged with residual dirt</td>
<td>Vacuum lines cleaned and operator finishing at briefings</td>
<td>in the finishing section</td>
<td>18-May-20</td>
<td>Maintenance</td>
<td>Vacuum finishing line cleaning and routine maintenance checks</td>
</tr>
<tr>
<td>2</td>
<td>The auger pugmill or extruder has worn more than 5 mm</td>
<td>Because 45,597 km have been used, it needs maintenance</td>
<td>Repair of the auger and maintenance standards were established</td>
<td>in the extruder</td>
<td>08-Jun-20</td>
<td>Maintenance</td>
<td>Repair of the auger by patching worn augers and making a pugmill wear checklist that converts from pcs to m for periodic maintenance</td>
</tr>
<tr>
<td>3</td>
<td>Operators in entering the feeder into the mold forming as long as it is not perpendicular.</td>
<td>Because the going in forming is not perpendicular because the pugmill operator is in a hurry to put the going into the lorry.</td>
<td>Pugmill operators are trained to put the going so as not to tilt.</td>
<td>on the pugmill section</td>
<td>08-Jun-20</td>
<td>Operator pugmill</td>
<td>Pugmill operator training for laying down and consistent monitoring of work by the Head of Formation.</td>
</tr>
<tr>
<td>4</td>
<td>Between the HG in the forming section and the seized part in the finishing section, the dimensions don’t match</td>
<td>By checking the results of the forming form are placed in seized, the result is that the tip of the skirt does not reach the confiscated stoper.</td>
<td>Repairs are carried out for classification and standards are made for maintenance.</td>
<td>in the finishing section</td>
<td>25-Jun-20</td>
<td>Maintenance operators</td>
<td>Use the checklist for use of HG and confiscated molds and check the similarity of dimensions of confiscated and HG after each use of 20,000 pcs for maintenance.</td>
</tr>
<tr>
<td>5</td>
<td>There is no torsional measurement for YG mold results</td>
<td>Because the most recent measurement is sufficient as a reference for checking the measured measurements.</td>
<td>Dikalkukan pengecekan untuk patuan YG dan operator diberi training.</td>
<td>in the forming section</td>
<td>23-Jun-20</td>
<td>Forming operator, Head of forming and QC</td>
<td>Making a check sheet for YG measurement and setting the rotation standard for YG, namely 90 degrees.</td>
</tr>
</tbody>
</table>

(Source: Data processing company, 2020)

Table 7: Table control after improvement

<table>
<thead>
<tr>
<th>No</th>
<th>Control</th>
<th>Tool</th>
<th>How to often</th>
<th>Checking</th>
<th>Who</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Vacuum</td>
<td>Maintenance checklist</td>
<td>Monthly</td>
<td>Vacuum duct</td>
<td>Maintenance</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Production checklist</td>
<td>Daily</td>
<td>Work consistency</td>
<td>Head of Forming Section</td>
</tr>
<tr>
<td>2</td>
<td>Auger</td>
<td>Extruder usage checklist</td>
<td>Monthly</td>
<td>Length's production go</td>
<td>Maintenance</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Production checklist</td>
<td>Daily</td>
<td>Work consistency</td>
<td>Head of Forming Section</td>
</tr>
<tr>
<td>3</td>
<td>Consistent insertion going into main forming</td>
<td>Production checklist</td>
<td>Weekly</td>
<td>Number of production</td>
<td>Forming operators, finishing and forming technicians</td>
</tr>
<tr>
<td>4</td>
<td>HG compatibility with data</td>
<td>Production checklist</td>
<td>Weekly</td>
<td>Number of production</td>
<td>Forming operators, finishing and forming technicians</td>
</tr>
<tr>
<td>5</td>
<td>TG twist</td>
<td>TG checking checklist</td>
<td>Daily</td>
<td>Degree of forming</td>
<td>Forming operator, Head of forming and QC</td>
</tr>
</tbody>
</table>

(Source: Data processing company, 2020)

Table 8: The table is the calculation result of DPO, DPMO and six sigma level after the upgrade stage.

<table>
<thead>
<tr>
<th>Proses</th>
<th>DPO</th>
<th>DPMO</th>
<th>Level Sigma</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural Drying</td>
<td>0.0038</td>
<td>3800.601</td>
<td>4.17</td>
</tr>
</tbody>
</table>

(Source: Data processing company, 2020)


[7]. Tri Hendradi, *Statistik Six Sigma denganminitahapbanduercerdasintiasitkualitas*. Yogyakarta : CV. ANDI


[15]. Hani Sirine, Elisabeth PentiKurniawati 2017, ‘PengendalianKualitasMenggunakanMetode Six Sigma (StudiKasuspadaproduction line shelter)’, *AJIE - Asian Journal of Innovation and Entrepreneurship* Vol. 02, No. 03.


APPENDIX 2

Before/After Binomial Capability Comparison for Reject before vs Reject after

Diagnostic Report

P Chart

Confirm that the Before and After process conditions are stable.

Before

After

Cumulative % Defective

As the points level out, the estimate of % defective becomes more reliable.

Before

After

Before/After Binomial Capability Comparison for Reject before vs Reject after

Summary Report

Reduction in Rate of Defective Items

% of defective items was reduced by 85% from 2.47% to 0.36%.

Is the % defective at or below 0.5%?

Yes

No

Process Characterization

<table>
<thead>
<tr>
<th>Before</th>
<th>After</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of subgroups</td>
<td>23</td>
</tr>
<tr>
<td>Average subgroup size</td>
<td>937.22</td>
</tr>
<tr>
<td>Total items tested</td>
<td>21326</td>
</tr>
<tr>
<td>Number of defectives</td>
<td>512</td>
</tr>
</tbody>
</table>

Process Capability (Overall)

<table>
<thead>
<tr>
<th>Process</th>
<th>Before</th>
<th>After</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>% Defective</td>
<td>2.47</td>
<td>0.38</td>
<td>-2.09</td>
</tr>
<tr>
<td>95% CI</td>
<td>(2.16, 2.48)</td>
<td>(0.38, 0.51)</td>
<td></td>
</tr>
<tr>
<td>PPM (DPMO)</td>
<td>24680</td>
<td>3801</td>
<td>-20879</td>
</tr>
<tr>
<td>Process Z</td>
<td>1.97</td>
<td>2.67</td>
<td>0.70</td>
</tr>
</tbody>
</table>

Comments

Before/Reject before

After/Reject after

Acceptable % defective 0.5%

• Before: The process % defective was not significantly less than the maximum acceptable level (p = 0.05).
• After: The process % defective is significantly less than the maximum acceptable level (p < 0.05).