Analysis of Quality Control Connecting Rod with Statistical Process Control (SPC) Method in PT.XYZ

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Abstract: Quality control of a product is very important to do that levels approaching zero defect generated. PT.XYZ produce connecting rod with a data defect during January 2015 - March 2015 as much as 7.47% of the total production of 26,070 pcs. The statistical methods used for data processing using methods of Statistical Process Control (SPC) or Control Chart, Process Capability and Fishbone Diagram. The decline in the number of visible defect after the repair to 3.65% of the total production of 27,053 pcs and the value of Process Capability (CP) rose from 0.26 to 1.27.

Keyword: Quality, Defect, Capability Process, Statistical Process Control (SPC) Method

1. Introduction

Quality control aimed at improving the quality of the product, should ideally be carried out at each stage of the process development and manufacture of such products. Thus the quality control should have started from the design, receipt of raw materials to the manufacturing process. To produce a good product as desired then quality control has been an absolute requirement. Quality control is important to be done by the company to the products produced in accordance with standards established by the company as well as standards set by local agencies and international managing of quality standardization / quality, and of course in accordance with what is expected by the consumer.

PT. XYZ as automotive companies that have international scale can not be liberated and be separated from the already very long journey for the existence of four-wheeled vehicles for this type of bus and truck in Indonesia. With the growing level of competition will require good quality control so that it can compete with products produced by other companies. Currently the products are of high quality is the key factor of success of competition.

2. Literature Review

2.1 Definition of Quality

"Quality is very important for a product, either in the form of goods and services. Things that are very important for manufacturers with regard to the products are: quality, cost and productivity. The quality is the ability of a product or service that consistently meets the expectations of consumers. Thus the quality is the only thing that matters most to both pihak. Dalam many cases, the concept of quality is different between manufacturers / producers and consumers "(Rev. Dorothea, 1999).

Definition of Statistical Quality Control "Statistical Process Control (SPC) is a process used to monitor the standards, make measurements and take corrective action while a product or service being produced" (Heizer and Barry Render, 2005.)

"Statistical quality control is a problem-solving techniques that are used to monitor, control, analyze, manage, and improve products and processes using statistical methods. Statistical quality control (statistical quality control) is often referred to as statistical process control (statistical process control). Statistical quality control and statistical process control is the two terms are interchangeable, which, if done together then the user will see the picture of the performance of the process of the present and the future. "(Feigenbaum, Armand V, 1991)

"Statistical quality control using SPC (Statistical Process Control) has seven (7) major statistical tools that can be used as tools for quality control, among others, namely; checksheet, histogram, control chart, Pareto diagram, cause and effect diagrams, scatter diagrams and process "(Garvin, David, 2001).

Figure 1: QC Seven Tool

2.2 Control Chart

"Control chart is a statistical method to distinguish the variation or deviation due to general causes and causes khusus. Peta describe improved quality control, consisting of two situations, the first is when the map control is made, the
process in unstable conditions. Conditions beyond the control limit occurs due to special causes (assignable cause), then look for corrective action so that the process becomes stable. The result is an improvement process. The control chart can be divided into two groups according to the type of data, namely a control chart for attribute data and control chart for variable data.” (Dorothea Revelation, 1999)

2.3 P Control chart

In analyzing the data of this study, use p control chart (control chart proportion of damage) as a tool for statistical process control. The use of p control map are due to the quality control is performed attributes, as well as data obtained as sample observation is not fixed and the product which has such damage can not be repaired anymore and should be rejected (reject).

2.4 Capability Process (Cp)

Process capability is the concept of process capability put forward in the early 1970s with the introduction “Capability Ratio” by Juran, a renowned authority on quality. After nearly 40 years on, many indexes such as Cp, Cpk and Cpm developed for the measurement process. Capability means the ability of a process of producing a product that meets specifications. If the process has a good capability, the process will generate located within the limits of the specification limits. Conversely if the process has the capability ugly, the process will produce who is beyond specification limits sehingga menimbulkan losses because many products that will be rejected. Process capability index (Cp) is calculated using the following formula:

\[
Cp = \frac{USL - LSL}{6\sigma}
\]

where:
- \(Cp\) = Capability Process
- USL = Upper Standard Limit
- LSL = Lower Standard Limit
- \(6\sigma\) = 6 Deviation

3. Methodology

The research methodology is the steps and plans of the thinking process in solving the problem, ranging from preliminary research, the discovery of the problem, observation, data collection both written and reference directly into the field of observation, data processing until the conclusion on the issues examined.
4. Discussion and Analysis

In the face of increasingly fierce competition, the company is expected to produce high quality products, in accordance with the standards set by the company and consumer demand. Therefore, the company must carry out quality control activities continuously to the product. The control carried out by the company, namely: Control of raw materials and the control of production processes, from the research, there are several much damage that occurs in product yield Connecting Rod, and is still quite high even exceeding the tolerance limit damage to the product specified by the company. Such damage can be complex or simple nature. The company should strive to be able to resolve problems that arise immediately. The types of defects that occur on the Connecting Rod, among others: Diameter Oval, not processed, rust, scratches and chipped.
Table 1: Number and type of disability

<table>
<thead>
<tr>
<th>Defect Condition</th>
<th>Amount Defect</th>
<th>% Defect</th>
<th>Akumulasi</th>
<th>% Akumulasi</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diameter Oval</td>
<td>1949</td>
<td>50%</td>
<td>1949</td>
<td>50%</td>
</tr>
<tr>
<td>Not processed</td>
<td>1109</td>
<td>28%</td>
<td>3058</td>
<td>78%</td>
</tr>
<tr>
<td>Rust</td>
<td>355</td>
<td>9%</td>
<td>3413</td>
<td>87%</td>
</tr>
<tr>
<td>Scratch</td>
<td>347</td>
<td>9%</td>
<td>3760</td>
<td>96%</td>
</tr>
<tr>
<td>Chipped</td>
<td>177</td>
<td>4%</td>
<td>3937</td>
<td>100%</td>
</tr>
<tr>
<td>Amount</td>
<td>3937</td>
<td>100%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Control Chart

The steps to create a control chart:

a. Calculating the center line / Central Line (CL)
   - Center line / Central Line is the middle line that was ushered upper control limit (UCL) and lower control limit (LCL). The center line is the line that represents the average level of damage in a production process. To calculate the center lines use the formula:
   \[ CL = \bar{p} = \frac{\sum np}{\sum n} \]

   Remark :
   \[ \sum n = \text{Amount of Checked} \]
   \[ \sum np = \text{Amount of Defect} \]

   Based on the above formula, found the Central Line (CL) as follows:
   \[ \sum np = 3937 \]
   \[ \sum n = 26070 \]
   \[ CL = \bar{p} = \frac{3937}{26070} = 0.151 \]

b. Calculating upper control limit Upper Control Limit (UCL)
   - To calculate the upper control limit (Upper Control Limit / UCL) conducted by the formula:
   \[ UCL = \bar{p} + 3 \left( \sqrt{\frac{\bar{p}(1-\bar{p})}{n}} \right) \]

   Remark :
   \[ \bar{p} = \text{Average of defect} \]
   \[ n = \text{Amount of production and etc...} \]

   c. Calculating the lower control limit or Lower Control Limit (LCL)
   - To calculate the lower control limit or LCL performed by the formula:
   \[ LCL = \bar{p} - 2 \left( \sqrt{\frac{\bar{p}(1-\bar{p})}{n}} \right) \]

   Remark :
   \[ \bar{p} = \text{Average of defect} \]
   \[ n = \text{Amount of production and etc...} \]

   note: If the LCL <0 then LCL considered = 0

   Then the calculation is as follows:

Based on these calculations, it was found that the value N ‘is smaller than the value of N is 9 <21, meaning that the data or samples collected are sufficient.
For the calculation of p control map which can be seen in the following table:

**Table 2: Calculation Period Month Limit Full Jan- March 2015**

<table>
<thead>
<tr>
<th>Tanggal Produksi (Jan-Mar'15)</th>
<th>Jumlah Produk (pcs)</th>
<th>Jumlah Produk Rusak (Defect) (pcs)</th>
<th>Presentasi Produk Rusak (Defect)</th>
<th>CL</th>
<th>UCL</th>
<th>ICL</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1303</td>
<td>177</td>
<td>0.135</td>
<td>0.05</td>
<td>0.95</td>
<td>0.90</td>
</tr>
<tr>
<td>2</td>
<td>1284</td>
<td>140</td>
<td>0.109</td>
<td>0.075</td>
<td>0.975</td>
<td>0.90</td>
</tr>
<tr>
<td>3</td>
<td>1372</td>
<td>152</td>
<td>0.111</td>
<td>0.075</td>
<td>0.975</td>
<td>0.90</td>
</tr>
<tr>
<td>4</td>
<td>1374</td>
<td>173</td>
<td>0.112</td>
<td>0.075</td>
<td>0.975</td>
<td>0.90</td>
</tr>
<tr>
<td>5</td>
<td>1040</td>
<td>165</td>
<td>0.159</td>
<td>0.075</td>
<td>0.975</td>
<td>0.90</td>
</tr>
<tr>
<td>6</td>
<td>1039</td>
<td>152</td>
<td>0.112</td>
<td>0.075</td>
<td>0.975</td>
<td>0.90</td>
</tr>
<tr>
<td>7</td>
<td>1300</td>
<td>162</td>
<td>0.124</td>
<td>0.075</td>
<td>0.975</td>
<td>0.90</td>
</tr>
<tr>
<td>8</td>
<td>1176</td>
<td>176</td>
<td>0.150</td>
<td>0.075</td>
<td>0.975</td>
<td>0.90</td>
</tr>
<tr>
<td>9</td>
<td>1288</td>
<td>156</td>
<td>0.121</td>
<td>0.075</td>
<td>0.975</td>
<td>0.90</td>
</tr>
<tr>
<td>10</td>
<td>1252</td>
<td>233</td>
<td>0.190</td>
<td>0.075</td>
<td>0.975</td>
<td>0.90</td>
</tr>
<tr>
<td>11</td>
<td>1228</td>
<td>202</td>
<td>0.194</td>
<td>0.075</td>
<td>0.975</td>
<td>0.90</td>
</tr>
<tr>
<td>12</td>
<td>1209</td>
<td>203</td>
<td>0.194</td>
<td>0.075</td>
<td>0.975</td>
<td>0.90</td>
</tr>
<tr>
<td>13</td>
<td>1188</td>
<td>218</td>
<td>0.216</td>
<td>0.075</td>
<td>0.975</td>
<td>0.90</td>
</tr>
<tr>
<td>14</td>
<td>1000</td>
<td>216</td>
<td>0.216</td>
<td>0.075</td>
<td>0.975</td>
<td>0.90</td>
</tr>
<tr>
<td>15</td>
<td>1192</td>
<td>227</td>
<td>0.190</td>
<td>0.075</td>
<td>0.975</td>
<td>0.90</td>
</tr>
<tr>
<td>16</td>
<td>1102</td>
<td>190</td>
<td>0.139</td>
<td>0.075</td>
<td>0.975</td>
<td>0.90</td>
</tr>
<tr>
<td>17</td>
<td>1228</td>
<td>214</td>
<td>0.174</td>
<td>0.075</td>
<td>0.975</td>
<td>0.90</td>
</tr>
<tr>
<td>18</td>
<td>1259</td>
<td>218</td>
<td>0.174</td>
<td>0.075</td>
<td>0.975</td>
<td>0.90</td>
</tr>
<tr>
<td>19</td>
<td>1252</td>
<td>213</td>
<td>0.174</td>
<td>0.075</td>
<td>0.975</td>
<td>0.90</td>
</tr>
<tr>
<td>20</td>
<td>1260</td>
<td>174</td>
<td>0.138</td>
<td>0.075</td>
<td>0.975</td>
<td>0.90</td>
</tr>
<tr>
<td>21</td>
<td>1260</td>
<td>223</td>
<td>0.190</td>
<td>0.075</td>
<td>0.975</td>
<td>0.90</td>
</tr>
<tr>
<td>TOTAL</td>
<td>2670</td>
<td>3987</td>
<td>3.203</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

From the calculation table 2 above, it can then be made p control map which can be seen in the image below:

**Figure 4: Map Control Defect proportion of the period Jan - March 2015**

Based on the above map image p control can be seen that the data obtained entirely outside the control limit that has been set even, so it can be said that the process is out of control.

**Analysis of Capability Process**

Activities that include statistical technique that is used all round the production process that includes development prior to production, in order to quantify process variability, variability analysis relative to the requirements or specifications of the product that is useful for the development and production in eliminating or reducing the amount of variability is called process capability analysis.

**Table 3: Data Inspection Connecting Rod Diameter Hole Model W04D Month January 2015 - March 2015 (Before Repair)**

<table>
<thead>
<tr>
<th>Tanggal Produksi (JANUARY)</th>
<th>Diameter Hole USL (0.065)</th>
<th>Diameter Hole LSL (-0.015)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>-0.005</td>
<td>-0.002</td>
</tr>
<tr>
<td>2</td>
<td>-0.007</td>
<td>-0.005</td>
</tr>
<tr>
<td>3</td>
<td>-0.008</td>
<td>-0.009</td>
</tr>
<tr>
<td>4</td>
<td>-0.007</td>
<td>-0.008</td>
</tr>
<tr>
<td>5</td>
<td>-0.007</td>
<td>-0.008</td>
</tr>
<tr>
<td>6</td>
<td>-0.006</td>
<td>-0.006</td>
</tr>
<tr>
<td>7</td>
<td>-0.006</td>
<td>-0.006</td>
</tr>
<tr>
<td>8</td>
<td>-0.006</td>
<td>-0.006</td>
</tr>
<tr>
<td>9</td>
<td>-0.006</td>
<td>-0.006</td>
</tr>
<tr>
<td>10</td>
<td>-0.006</td>
<td>-0.006</td>
</tr>
<tr>
<td>11</td>
<td>-0.006</td>
<td>-0.006</td>
</tr>
<tr>
<td>12</td>
<td>-0.006</td>
<td>-0.006</td>
</tr>
<tr>
<td>13</td>
<td>-0.006</td>
<td>-0.006</td>
</tr>
<tr>
<td>14</td>
<td>-0.006</td>
<td>-0.006</td>
</tr>
<tr>
<td>15</td>
<td>-0.006</td>
<td>-0.006</td>
</tr>
<tr>
<td>16</td>
<td>-0.006</td>
<td>-0.006</td>
</tr>
<tr>
<td>17</td>
<td>-0.006</td>
<td>-0.006</td>
</tr>
<tr>
<td>18</td>
<td>-0.006</td>
<td>-0.006</td>
</tr>
<tr>
<td>19</td>
<td>-0.006</td>
<td>-0.006</td>
</tr>
<tr>
<td>20</td>
<td>-0.006</td>
<td>-0.006</td>
</tr>
<tr>
<td>21</td>
<td>-0.006</td>
<td>-0.006</td>
</tr>
</tbody>
</table>

Based on the above data it can be seen:

1. **Capability Process (CP) Connecting Rodon January 2015** prior to the change as follows:
   
   USL = 0
   
   LSL = -0.015

   With an average of Data= -0.017
   
   Standar Deviation (σ) = 0.024

   a. Process Capability Ratio or Capability Process Index / Cp

   \[
   Cp = \frac{USL - LSL}{6\sigma} = \frac{0 - (-0.015)}{0.024} = 0.102
   \]

   So, Cp < 1 , process incapable
b. Upper and lower capability index
\[ \text{CPL} = \frac{\mu - LSL}{3\sigma} = \frac{0.017 - (-0.015)}{3 \times 0.024} = -0.029 \]

Whereas if Minitab software are as follows:

3. Capability Process (CP) Connecting Rodon Maret 2015 prior to the change as follows:

\[ \text{USL} = 0 \]
\[ \text{LSL} = -0.015 \]

With an average of Data = -0.007
Standar Deviation (σ) = 0.014

a. Process Capability Ratio or Capability Process Index / Cp
\[ \text{Cp} = \frac{\text{USL} - \text{LSL}}{6\sigma} \]
\[ = \frac{0 - (-0.015)}{6 \times 0.014} \]
\[ = 0.182 \]

So Cp < 1, process incapable
b. Upper and lower capability index
\[ \text{CPU} = \frac{\text{USL} - \mu}{3\sigma} = \frac{0 - (-0.009)}{3 \times 0.014} \]
\[ = 0.218 \]
\[ \text{CPL} = \frac{\mu - \text{LSL}}{3\sigma} = \frac{-0.009 - (-0.015)}{3 \times 0.014} \]
\[ = 0.145 \]

c. Cpk index
\[ \text{Cpk} = \min \left( \frac{\text{USL} - \mu}{3\sigma}, \frac{\mu - \text{LSL}}{3\sigma} \right) \]
\[ = \min (0.218, 0.145) \]
\[ = 0.145 \]

Cpk ≤ 1, process incapable
Whereas if Minitab software are as follows:

Table 4: Data Inspection Connecting Rod Diameter Hole Model W04D Month April 2015 - June 2015 (After Repair)

Based on the above data it can be seen:
1. Capability Process (CP) Connecting Rod on April 2015 prior to the change as follows:

- USL = 0
- LSL = -0.015
- Average of Data = -0.009
- Standard Deviation (σ) = 0.002

a. Process Capability Ratio or Capability Process Index / Cp

\[ Cp = \frac{USL - LSL}{6\sigma} \]

\[ = \frac{0 - (-0.015)}{6 \times 0.002} \]

\[ = 1.069 \]

So \( Cp > 1 \), process capable

b. Upper and lower capability index

\[ CPU = \frac{USL - \mu}{3\sigma} = \frac{0 - (-0.009)}{3 \times 0.002} = 1.303 \]

\[ CPL = \frac{\mu - LSL}{3\sigma} = \frac{-0.009 - (-0.015)}{3 \times 0.002} = 0.835 \]

c. Cpk index

\[ Cpk = \min\left(\frac{USL - \mu}{3\sigma}, \frac{\mu - LSL}{3\sigma}\right) \]

\[ = \min\left(\frac{1.303}{3 \times 0.002}, \frac{0.835}{3 \times 0.002}\right) \]

\[ = 0.835 \]

So \( Cpk \geq 1 \), process capable

Whereas if Minitab software are as follows:

2. Capability Process (CP) Connecting Rod on May 2015 prior to the change as follows:

- USL = 0
- LSL = -0.015
- Average of Data = -0.008
- Standard Deviation (σ) = 0.002

a. Process Capability Ratio or Capability Process Index / Cp

\[ Cp = \frac{USL - LSL}{6\sigma} \]

\[ = \frac{0 - (-0.015)}{6 \times 0.002} \]

\[ = 1.337 \]

So \( Cp > 1 \), process capable

b. Upper and lower capability index

\[ CPU = \frac{USL - \mu}{3\sigma} = \frac{0 - (-0.008)}{3 \times 0.002} = 1.385 \]

\[ CPL = \frac{\mu - LSL}{3\sigma} = \frac{-0.008 - (-0.015)}{3 \times 0.002} = 1.288 \]

\[ Cpk = \min\left(\frac{USL - \mu}{3\sigma}, \frac{\mu - LSL}{3\sigma}\right) \]

\[ = \min\left(1.385, 1.288\right) \]

\[ = 1.288 \]

So \( Cpk \geq 1 \), process capable

Whereas if Minitab software are as follows:

3. Capability Process (CP) Connecting Rod on June 2015 prior to the change as follows:

- USL = 0
- LSL = -0.015
- Average of Data = -0.009
- Standard Deviation (σ) = 0.002

a. Process Capability Ratio or Capability Process Index / Cp

\[ Cp = \frac{USL - LSL}{6\sigma} \]

\[ = \frac{0 - (-0.015)}{6 \times 0.002} \]

\[ = 1.364 \]

So \( Cp > 1 \), process capable
b. Upper and lower capability index

\[
\begin{align*}
\text{CPU} &= \frac{\text{USL} - \mu}{3\sigma} = \frac{100 - 99.998}{0.002} = 1.713 \\
\text{CPL} &= \frac{\mu - \text{LSL}}{3\sigma} = \frac{99.998 - 99.995}{0.002} = 1.015 \\
\text{Cpk} &= \min \left( \frac{\text{CPU}}{3\sigma}, \frac{\text{CPL}}{3\sigma} \right) = \min \left( 1.713, 1.015 \right) = 1.015
\end{align*}
\]

Thus the diagram can be used to explain the causes of a problem.

6. Suggestion

Need to do continuous improvement (continuous improvement) that better quality performance in the future.

References


Author Profile

Nanang Supriana, received the ST. from Industrial Engineering STT. Wastukancana Purwakarta, West Java, Indonesia.

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Osep Hijuzaman received the S.Pd., M.T, Lecture of STT. Wastukancana Purwakarta, West Java, Indonesia. I had studied in Electrical Engineering Education from University of Indonesia in Bandung (1999) and Magister Industrial Engineering and Management from Pasundan University (2007), now studying at the University of Indonesia in Bandung, Doctoral Program in Management of Science.