Production Quality Control Using Six Sigma Method in Shock Absorber Industry (Case Study at PT.XYZ)

Patrik Martahi Ignatius$^1$, Hadi Sutanto$^{2*}$

$^1$Department of Mechanical Engineering, Atma Jaya Catholic University of Indonesia, Jl. Jenderal Sudirman 51, Jakarta, 12930, Indonesia.

$^{2*}$Corresponding Author.

Abstract

PT.XYZ as a distributor for manufacturing vehicle shock absorber parts has a problem with the production front fork parts, namely a leak in the area above the front fork found in the claim market. Researchers used the DMAIC method, where there are steps to reduce defects and variations carried out systematically by defining, measuring, analyzing, improving, and controlling which are known as the 5 phases of DMAIC (Define, Measure, Analysis, Improvement, Control). Research and data collection were taken from one of the claim market cases at PT. XYZ and PT Astra Honda Motor for the period January to December 2019. The results showed that after the define and measure process was carried out, 2 main problems were found that caused the front fork to leak in the upper area, namely a defective o-ring condition and minus inner tube dimensions. This is evidenced by the measurement of process capability, where the defective o-ring conditions obtained Cp 0.62 and Cpk 0.58 and for the dimensions inner tube minus, the Cp values were 9.4 and Cpk 0.24. After that, from the 2 problems, an analysis was carried out and the factors that caused the o-ring defect and the minus inner tube dimensions were analyzed. In the defective o-ring, there is a condition that exceeds the lifetime, and the dies that are not clean cause the o-ring to be defective. So that the addition of control over the replacement of dies and socialization related to the cleanliness of dies. For the problem of minus inner tube dimensions, it is caused when tools change is not reset, from these findings, a document for tool change control is made.

Keywords: Front Fork, Leak, DMAIC

1. INTRODUCTION

The production process has a very important role in keeping the products produced following specifications, but there are still products that do not comply with established standards or defective products [1]. The existence of defects found in the product will have an impact on the addition of production costs which are considered as waste and cannot use resources properly. Quality control is a process or activity to ensure that the quality of each product is following predetermined specifications based on company regulations.

PT XYZ is a distributor for the manufacture of shock absorber parts for motorized vehicles, both two-wheeled and four-wheeled vehicles, in collaboration with several manufacturing companies in the automotive sector to support the motorcycle assembly process. PT XYZ is responsible for any complaints from consumers regarding the use of motorbikes and is obliged to make repairs to be able to maintain trust with cooperating companies. To obtain production quality, a sustainable product quality control method is needed, one of which is the six sigma method. The main objective of this research is to analyze the quality of a part of a motorcycle through the DMAIC phase (Define, Measure, Analyze, Improve, Control). One type of consumer complaint (claim market) that requires serious handling is the Front Fork (Figure 1.1) with the problem of a leak in the Upper area (marked in red) which occurs in all types of motorbikes. Front Fork (Shock Absorber) is an important component of a vehicle's suspension system, which functions to dampen the oscillating force of the spring. The front fork slows down and reduces the magnitude of vibration - motion, by converting the kinetic energy from the suspension movement into heat energy that can be dissipated through hydraulic fluids [2].

Figure 1: Part Front Fork (left) and Upper Front Fork Leaking Area (right)

From the results of research conducted by Hidayat [3] using Minitab software on the KVL type L type crankcase, it was found that the average process in the die casting section resulted in a total defect of 2473 for the period January to March 2008, which is the company’s benchmark for improvement. The application of DMAIC can increase effectiveness while providing adequate reactions to problems that arise (Smętkowska and Mrugalska, 2018) as well as identifying the optimal level of tolerance and opportunities for
improvement [4].

1. Knowing the type of defect that causes the front fork in the upper area.
2. Identify the biggest factor causing the front fork in the upper area.
3. Formulate corrective actions and make improvements in the company to eliminate the leaky front fork problem in the upper area.
4. Comparing CP / CPk before and after repairs.

Based on previous research, my research this time is at the measurement stage. I use process capability tools because the analysis that will be carried out ensures that the process capability of a machine is up to standard or not. And the second difference is in the control tools stage that is used using SPC (Statistical Process Control) where from this control the consistency of improvement can be controlled every day.

2. RESEARCH AND METHOD

Six Sigma is a method used to identify problems in the production process and describe burdensome defects in terms of time, money, customers, and opportunities (Supriyadi, 2017). Kibria, Kabir, & Boby (2014) revealed that Six Sigma increases profit margins, improves financial conditions by minimizing the level of product defects. Researchers used the DMAIC method, where there are steps to reduce defects and variations carried out systematically by defining, measuring, analyzing, improving, and controlling which are known as the 5 phases of DMAIC (Define, Measure, Analysis, Improvement, Control). Research and data collection were taken from one of the claim market cases at PT. XYZ and PT Astra Honda Motor from January to December 2019.

3. RESULTS

3.1. Define

In 2019, consumer complaints (Claim Market) were found with complaints received due to the front fork leaking in the upper area which can be seen in table 1. below this

<table>
<thead>
<tr>
<th>Tahun 2019</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motor Matic</td>
<td>86</td>
<td>74</td>
<td>89</td>
<td>81</td>
<td>85</td>
<td>90</td>
<td>75</td>
<td>82</td>
<td>78</td>
<td>83</td>
<td>70</td>
<td>960</td>
<td></td>
</tr>
<tr>
<td>Motor Manual</td>
<td>15</td>
<td>18</td>
<td>22</td>
<td>17</td>
<td>24</td>
<td>21</td>
<td>15</td>
<td>21</td>
<td>26</td>
<td>14</td>
<td>13</td>
<td>230</td>
<td></td>
</tr>
<tr>
<td>Jumlah</td>
<td>101</td>
<td>92</td>
<td>111</td>
<td>98</td>
<td>109</td>
<td>101</td>
<td>99</td>
<td>97</td>
<td>99</td>
<td>108</td>
<td>97</td>
<td>83</td>
<td>1190</td>
</tr>
</tbody>
</table>

To define the process of the front fork components and parts associated with the front fork, starting from material suppliers, sub-parts, front fork assy, assy units, output distribution to consumers, a map of Supplier, Input, Process, Output, Customers (SIPOC) will be made diagram which can be seen in Figure 4 below

3.2. Measure

At the Measure stage, the main activity carried out is the measurement of calculating the capability process condition where the output is the value of Cp, Cpk. The processing capability will be calculated first by mapping the part process,

Figure 2: Logic Tree Diagram Penyebab Front Fork Bocor Area Upper

Figure 3: Front Fork Upper Area

Figure 4: SIPOC Diagram
then determining the critical point by making a logic tree diagram on the part process. The processing capability that will be calculated includes:

1. O Ring Dimensions
2. Inner Tube Dimensions
3. Cap Dimensions

Dimensional Measurement of O Ring

Measurement of process capability that is measured is the points that affect the density with the inner tuber, including:

1. Inside Diameter
2. Ring Diameter

For CP o-ring measurement, it will involve 2 suppliers, namely Supplier A and Supplier B. Standard dimensions of the inside diameter and ring diameter can be seen in Figure 5 below.

Based on the above calculations, the Cp value is 0.85 and the Cpk is 0.72, with the Cp Cpk value obtained, it can be concluded that the results of the Process are Enough and it is decided OK.

Next, taking Cp, Cpk, calculating the ring diameter for supplier A can be seen in Figure 7 below.

Based on the above calculations, the Cp value is 0.62 and Cpk 0.58. From these results, it can be decided that the process is not good and it is decided by NG.

Furthermore, the calculation of Cp, Cpk starts on the diameter of the ring cap for supplier B which can be seen in Figure 8 below.

Based on calculations on supplier B, the Cp value is 5.34 and the Cpk value is 5.28, with the Cp Cpk value obtained, it can be concluded that the results of the Process are Very Good and it is decided that the results of the process are OK.

And taking Cp, Cpk, the last calculation is done on the ring diameter for supplier B which can be seen in Figure 9 below.
Based on calculations on supplier B, the Cp value is 5.34 and the Cpk value is 5.28, with the Cp Cpk value obtained, it can be concluded that the results of the Process are Very Good and it is decided that the results of the process are OK.

And taking Cp, Cpk, the last calculation is done on the ring diameter for supplier B which can be seen in Figure 10 below.

**Figure 10: Graphic Data Cp, Cpk Diameter Ring O Ring Supplier B**

Based on the latest calculations for the ring diameter at supplier B, the Cp value is 3.10 and the Cpk value is 2.77. Thus it can be concluded that the result of the Process is Very Good and it was decided OK.

**Inner Tube Dimension Measurement**

Measurement of process capability is measured on the inner tuber part, namely the inside upper diameter as seen in Figure 11 below.

**Figure 11: Standard Dimension Inside Upper Diameter**

Calculation of Cp, Cpk on the inside upper diameter can be seen in Figure 12 below.

**Figure 12: Graphic Data Cp, Cpk Inside Upper Diameter**

Based on the calculation of Cp, Cpk, the value of Cp is 9.4 and Cpk is 0.24. Because the Cpk value is below 0.67, it can be stated that the result of the process is not good and it is decided by NG.

**Measurement of Cap Dimensions**

The measurement of the front fork cap, especially on the outside diameter, is carried out on the part claim, in this part measurement, the process capability measurement is not carried out and the process mapping is carried out because the components of this part are imported so that the manufacturing process cannot be analyzed, if a problem is found on the dimensions then a claim or rejection will be made to the part maker. The measured part claim can be seen in Figure 13 below and the results of measuring part claim as many as 10 parts can be seen in Table 2.

**Figure 13: Cap Front Fork Illustration**

**Table 2: Measurement Data Market Claim Front Fork Part**

<table>
<thead>
<tr>
<th>No</th>
<th>Inspection Item</th>
<th>Standard</th>
<th>Measurement Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Grooving Diameter</td>
<td>15.6 ± 0.01</td>
<td>15.39 15.4 15.41 15.42 15.43 15.44 15.45 15.46 OK</td>
</tr>
<tr>
<td>3</td>
<td>Total Length</td>
<td>35.62 35.13 35.12 35.11 35.1 35.09 35.08 35.07 35.06 OK</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Width of Grooving</td>
<td>3.01 ± 0.01</td>
<td>3.02 3.03 3.04 3.05 3.06 3.07 3.08 3.09 3.10 OK</td>
</tr>
</tbody>
</table>

Based on the above measurement data, especially in the diameter grooving area where the 0 ring is installed, dimensionally there are no dimensional problems so that the conclusion on the front fork cap part is declared OK and no further analysis is needed.
3.3. Analyze

The main activity at the Analyze stage is to determine the factors that affect the front fork leak in the upper area based on the results of the previous stage, namely measurement. The following is a technical analysis based on measurement results on part components that affect the performance of the front fork which can cause the front fork to leak in the upper area.

Table 3: Technical Analysis for Front Fork Leak Upper Area

<table>
<thead>
<tr>
<th>Main Problem</th>
<th>Potential Problem</th>
<th>Judge (measurement)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>O-Ring Supplier A</td>
<td>Inside O-Ring Diameter</td>
<td>NG</td>
<td>Supplier Measurement-Based</td>
</tr>
<tr>
<td>O-Ring Supplier B</td>
<td>Cap Diameter</td>
<td>OK</td>
<td>Supplier Measurement-Based</td>
</tr>
<tr>
<td>O-Ring Supplier B</td>
<td>Inside O-Ring Diameter</td>
<td>OK</td>
<td>Supplier Measurement-Based</td>
</tr>
<tr>
<td>Press Process</td>
<td>Cap Diameter</td>
<td>OK</td>
<td>Supplier Measurement-Based</td>
</tr>
<tr>
<td>Man Power</td>
<td>Dimension inside Upper Diameter</td>
<td>NG</td>
<td>Measurement Part Claim Based</td>
</tr>
<tr>
<td>Cap Dimension</td>
<td>Dimension</td>
<td>OK</td>
<td>Measurement Part Claim Based</td>
</tr>
</tbody>
</table>

To resolve the indication of the front fork leak in the upper area based on the technical analysis table above, the analysis stage, the main tool to be used is as follows:

- **Cause and Effect Diagram (Fishbone Diagram)**
- **Failure Tree Analysis (FTA)**
- **Failure Mode and Effect Analysis (FMEA)**

Analysis of O Ring Defects

For the analysis of o ring defects using a cause and effect diagram to find the dominant factor that allows arising based on 5M + 1E, in this diagram, the 5M + 1E factor to be analyzed is the pressing process where the process greatly affects the quality of the o ring which can be seen in Figure 14 below.

After obtaining the causal diagram, the next step is to calculate the failure mode effect and analysis (FMEA). Failure Mode and Effect Analysis (FMEA) is used to see which part of the process is the most dominant in producing process failures where this time the process is in the pressing process. From the Failure Mode and Effect Analysis (FMEA), a table will be created to see the grouping carried out in Table 4 below.

Table 4: Minus Inner Tube Diameter Analysis

<table>
<thead>
<tr>
<th>No</th>
<th>Process Step</th>
<th>Potential Failure Mode</th>
<th>Potential Failure Effect</th>
<th>Potential Causes</th>
<th>Current Control</th>
<th>DRIFTEN</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Dies Process</td>
<td>Die Worn Out</td>
<td>O-Ring Defect</td>
<td>Maintenance not Done</td>
<td>10</td>
<td>No Inspection</td>
</tr>
<tr>
<td>2</td>
<td>Parameter Process</td>
<td>Out of Order Display</td>
<td>O-Ring Defect</td>
<td>Maintenance not Done</td>
<td>2</td>
<td>Incompliant Control</td>
</tr>
<tr>
<td>3</td>
<td>Press Process</td>
<td>Lack of press</td>
<td>O-Ring Defect</td>
<td>Setting parameter processes</td>
<td>4</td>
<td>Part Inspection</td>
</tr>
<tr>
<td>4</td>
<td>Dies Process</td>
<td>Dirty O-Ring</td>
<td>O-Ring Defect</td>
<td>Dealing was not done</td>
<td>5</td>
<td>Man Power don't Follow SOP</td>
</tr>
</tbody>
</table>

The analysis is also carried out the same as the previous part using the fishbone diagram. In the Fishbone Diagram for the minus inner tube problem, the same as the previous diagram the dominant factors that cause problems based on 5M + 1E will be analyzed based on the machining process. The cause and effect diagram of the minus inner tube can be seen in Figure 15 below.

Table Failure Mode Effect and Analysis (FMEA) Machining Process

The last analysis process is calculating the Failure Mode Effect and Analysis (FMEA) Machining Process after the previous
process the causes of the minus inner tube diameter have been obtained through the analysis of the causal diagram (Fishbone Diagram). The calculation of Failure Mode Effect and Analysis (FMEA) can be seen in Table 5 below.

**Table 5: Failure Mode Effect and Analysis (FMEA) Machining Process**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Inner Diameter</td>
<td>Resetting was not done</td>
<td>Minus Diameter</td>
<td>Cutting tool over use</td>
<td>10</td>
<td>No Resetting</td>
<td>8</td>
<td>640</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Inner Diameter</td>
<td>Excessive life time</td>
<td>Minus Diameter</td>
<td>Blunt Cutting tool</td>
<td>2</td>
<td>Periodic Inspection</td>
<td>5</td>
<td>50</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Dimension</td>
<td>Dimension out of spec</td>
<td>Minus Diameter</td>
<td>Cutting tool over use</td>
<td>10</td>
<td>Incomplet Final Inspection</td>
<td>5</td>
<td>400</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3.4. Improve

Based on the FMEA table that has been created, the following table of technical analysis (5-why method) and priority based on the value of the Risk Priority Number (RPN) on the factors that cause front fork leaks in the upper area can be seen in Table 6.

**Table 6: 5 Why Method Front Fork Leak Upper Area**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>O Ring Defect</td>
<td>Diameter O Ring out of standard</td>
<td>Worn Out</td>
<td>Maintenance not Done</td>
<td>Tidak ada dies inspected</td>
<td>640</td>
<td></td>
</tr>
<tr>
<td>Dirty Dies</td>
<td>Cleaning was not Done</td>
<td>Max Power</td>
<td>don't Follow SOP</td>
<td>250</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No Resetting</td>
<td>Inner tube</td>
<td>Dimension</td>
<td>Incomplet Final Inspection</td>
<td>640</td>
<td></td>
<td></td>
</tr>
<tr>
<td>There's Gap in inner tube</td>
<td>Minus</td>
<td>Diameter</td>
<td>Incomplet Final Inspection</td>
<td>400</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Improved Dies Use Control During O-Ring Making Process and SOP Socialization

In the press process of making an O ring, there are important things that have been previously discussed at the analysis stage that the use of dies is very important in manufacturing. After analysis, the cause of the CP / CPK NG on the ring diameter was caused by the use of the dies itself. When checking the dies, a worn condition is found which can be seen in Figure 16

![Figure 16: Dies at Press Process](image)

With the condition of the dies that are worn out, when the pressing process takes place the result of the O ring is defective. This defect in the O ring causes oil to come out. The cause of the worn condition of the dies due to the usage that exceeds the lifetime, this condition can be seen in Figure 17 where the condition of the dies exceeds the lifetime.

![Figure 17: Check Sheet dan Maintenance Schedule Dies](image)

From the above findings, it can be seen that in the 3rd week of March, there were conditions for the use of dies that exceeded the plan or standards set by production. From the condition of the dies that exceed the lifetime, the parts produced have visual defects which can be seen in Figure 18 below.

![Figure 18: Defect Rubber Trigger by Worn Out Dies](image)

With the discovery of worn-out dies conditions that were not detected by the operator, it is necessary to improve the control of the use of dies to avoid the reoccurrence of worn-out dies. Apart from that, the conditions that need to be maintained by the operator are related to the cleanliness of the dies, the condition of the dies where the remaining burry from the previous process can also cause the condition of the O ring to have defects. So that re-socialization is needed for operators so that no important processes in the SOP are missed. Re-socialization has been carried out and can be seen in Figure 19

![Figure 19: SOP Press Process Socialization](image)

Improved Control of Tool Change and Addition of Final Inspections

Repair activities that will be carried out this time are to fix problems that occur in the inner tube dimension. The inner tube
dimension itself is found in the bar in (inside diameter) process, which has a gradual infeed

After the analysis was carried out, there was a finding that when the tools were replaced, the operator did not set the offset wear, which caused an insert over to be carried out at the beginning of the feeding process. This is found when the operator has replaced the worn insert with a new insert, the operator does not set the offset wear and is shown on the monitor parameter setting in Figure 20 below

Figure 20: Monitor Setting Parameter Before dan After Change Insert

From the above findings, when a new insert is not set the offset wear is set, it will cause when the initial infeed process is carried out the result of the part dimensions will be minus. For the standard diameter itself between 21.6 - 21.7, if the operator compares the results of the insert insertion before it is replaced and after the insert is replaced.

Finding these conditions can cause the inner tube diameter to be minus and cause a leak in the front fork. In the IK (Work Instructions) document, the replacement of the insert tool is not written in detail, so it needs to be revised for the point of adding the insert tool settings when the replacement is made.

After repairs have been made which causes the inner tube diameter to be minus, it is followed by inspection of the parts so that if the same problem occurs, the operator can catch the NG part. To better control the production results maximally, improvements were made by adding 100% plug gauge checks and when there was a change of inserts, the dimensions were checked which can be seen in Figure 21 below.

Figure 21: Inspection Manual Revision Inner Tube Part

3.5. Control

The main activity in the control stage is to maintain and maintain the condition of the repair results. Process control is carried out using tools from SPC (Statistical Process Control), using the X-R Control Chart. The points to be controlled include:

Ring Diameter O Ring on the Front Fork which can be seen in Table 7

Table 7: X-R Control Chart Ring Diameter O Ring

Dimensions of Inside Upper Diameter on the Front Fork which can be seen in Table 8.

Table 8: X-R Control Chart Dimension Inside Upper Diameter
From the results of the X-R Chart, it can be seen that the data retrieval was carried out 4 times a day for 1 month, showing very good results. This control can be a reference that the improvements made can run well.

4. SUMMARY AND CONCLUSION

From the Define, Measurement and Analyze processes, researchers found 2 factors that caused the front fork to leak in the upper area. Where the first cause is due to a defective o-ring condition and the second cause is the minus dimensions of the inner tube. For this reason, the researcher carried out an improvement process, namely for the cause of the defect o-ring, control of the use of dies was carried out during the o-ring manufacturing process and carried out re-socialization for the SOP in the dies cleaning process after the pressing process was complete. And other causes related to the minus inner tube dimensions, improvements were made to control tool change in the machining process, and the addition of final inspection controls for the results of the machining process.

It is hoped that PT. XYZ will pay more attention and improve the performance of workers so that it can reduce defects in the production process. The need for PT XYZ’s involvement and providing training for employees to be able to participate in improving the six sigma method.

REFERENCES


