Implementation of Six Sigma with FMEA (Failure Mode and Effect Analysis) Method for Improving Product Quality of Electronic Components of Capacitors

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Abstract: In an increasingly competitive global competitive situation, the issue of product quality becomes a central issue for every company. The ability of the company to provide quality products will be a weapon to win the competition, because by providing products that the quality of customer satisfaction will be achieved. Therefore, attention to product quality can give a positive impact to the development and progress of the company's business; this condition requires a company to process all resources owned optimally and make continuous improvement to the existing working system effectively and efficiently. This research was conducted at PT. XYZ by implementing Six Sigma with FMEA (Failure Mode and Effect Analysis) method, which aims to identify any non-conformity product available in the capacitor electronic component product, measure initial condition and analyze the cause of existing problems and can be made possible measure of improvement outstanding quality with an actual breakthrough strategy. Six Sigma step is defined, Measure, Analyze, Improve and Control (DMAIC) and one of the methods used in analysis phase is FMEA (Failure Mode and Effect Analysis). The use of FMEA is used for cause and determination analysis with a DPMO (Defect Per Million Opportunities) decrease based on priority scale on RPN (Risk Priority Number) value. Implementation of Six Sigma method successfully implemented well this is marked by the existence of improving product quality. This condition can be clearly seen from the decrease of DPMO (Defect Per Million Opportunities) of 15,410 ppm to 2,8 ppm along with a continuous improvement result from cause analysis by using FMEA (Failure Mode and Effect Analysis) where priority scale based on Value RPN (Risk Priority Number). With the decline of DPMO dramatically then in itself there is a significant decrease in failure costs, which impact on improving the company's business and brought a good reputation within the company in accordance with the vision of the company became the world's number one Capacitor and Varistor manufacturing company.

Keywords: Six Sigma, DMAIC, FMEA, DPMO, RPN

1. Introduction

At this time, all companies are required to produce a product or service that has high quality from the results of its production activities. Product quality is an effort of company in giving satisfaction to its customer. The level of customer satisfaction is always evolving along with the increasing experience customers consumed a product positioned the company to always strive to improve the quality of its products. One of the efforts made by the company in improving the quality of its production is through quality control in the production process.

One of the important factors used to produce quality products by implementing the right quality control system, has a clear objective and stages, and able to provide breakthroughs in preventing and solving problems faced by companies through quality management.

Lots of systems / methods that manage or discuss quality management with their own characteristics. One of the new breakthroughs of quality management systems in the form of quality control that gives dramatic results is by applying the Six Sigma method. Six Sigma is a methodology, statistical analysis tool and management system designed to streamline business processes by eradicating defects. The implementation of Six Sigma aims to improve and maintain quality, eliminate waste and increase profits. This is achieved by: Reduced variation in process, Measurement, analysis, improvement and process control, and Involvement and dedication from all organizations including top management.

Measured and defective processes are recorded; the goal of Six Sigma is to operate processes with fewer than 3.4 defects per one million PT opportunities. XYZ is a company engaged in the electronic Measured and defective processes are noted, the goal of Six Sigma is to operate processes with fewer than 3.4 defects per one million occasions.

PT. XYZ is a company engaged in the electronic component industry and is a company with market share of electronics companies spread all over the world. The customers of PT. XYZ, among others, PT. A, PT. B, PT. C, and others.

PT. XYZ itself produces two types of products: DCC (disc ceramic capacitor) and DCV (disc ceramic varistor) with an average production capacity of 150,000,000 pcs per month, with DCC (disc ceramic capacitor) production capacity reaching 80%. The production of DCV (disc ceramic varistor) is only 20%. This is what makes the basic improvements to the product capacitor or DCC (disc ceramic capacitor) which has a larger production capacity as an observation / research in terms of quality improvement.
Disc Ceramic Capacitor manufactured by PT. XYZ consists of more than one hundred kinds of specifications depending on its electrical properties. But this type of Disc Ceramic Capacitor is classified into 3 main classes, according to Table 1.

Table 1. Products of PT. XYZ

<table>
<thead>
<tr>
<th>Product Type</th>
<th>Class</th>
<th>Spec</th>
<th>Class Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ceramic Capacitor</td>
<td>C1</td>
<td>EC</td>
<td>Temperature Compensating Ceramic</td>
</tr>
<tr>
<td></td>
<td>C2</td>
<td>EK</td>
<td>High Dielectric Constant Ceramic</td>
</tr>
<tr>
<td></td>
<td>C2</td>
<td>EKR</td>
<td>Low Loss Ceramic Capacitor</td>
</tr>
<tr>
<td>Ceramic Varistor</td>
<td>C2</td>
<td>SD/SC</td>
<td>AC Capacitor</td>
</tr>
<tr>
<td></td>
<td>C3</td>
<td>SVC</td>
<td>Disc Varistor</td>
</tr>
</tbody>
</table>

2. Literature Review

Six Sigma has 5 basics to improve, maintain quality, eliminate waste and increase profits. The foundation is DMAIC. DMAIC stands for: Define opportunity, Measure performance, Analyse opportunity, Improve performance and Control performance.

2.1 Define

The initial step of implementing the six sigma project is the define stage, which includes the following steps: 1. Identify the problem, 2. Determining the characteristics of quality, 3. Process mapping, 4. Determination of the project theme, 5. Determining the project team, 6. Determining the implementation schedule, 7. Determining the achievement of the target.

2.2 Measure

This stage is the stage of measurement or calculation of the data that has been measured. Calculation of process capability conditions before repair. Here are some steps in the Measure step: 1. Observation of initial conditions 2. Capability Analysis 3. Calculating Defect per million opportunities

2.3 Analyse

The next stage is Analyse which is the selection of factors that influence the critical point on quality. The problems that will arise and the potential factor x against the process will be solved

2.4 Improve

Using data from the execution of previous stages may now be able to improve the process by designing creative solutions to fix and prevent problems. This is achieved by: 1. Using discipline and technology to develop innovative solutions 2. Develop and implement plans

2.5 Control

Overseeing and sustaining improvements over time by: 1. Preventing the instinct to go back to the old ways of doing improvements. 2. Develop, document and implement a monitoring plan 3. Integrate the improvement of the entire company through the use of training and incentives. Implementation of DMAIC Rule we can use 7 QC tool for the project.

3. Methodology

In this enlisting, there are steps that due to be able to finish the research well. Stages of research in general are:

1. Formulation of the problem
   - The formulation of this problem how to improve the quality of production with six sigma.
2. Determining Research Objectives
   - It is certain that the purpose of this research in order to overcome the problems of product quality. By applying Six Sigma well we can see how big improvement of product quality.
3. Project Selection
   - The selection of this project is viewed from the capacity and condition of quality that is being bad at that time in accordance with existing data.
4. Step Six Sigma Step By executing
   - The five basic steps Six Sigma DMAIC (Define, Measure, Analyze, Improve and Control) can take what steps should be done during the project
5. Analysis and discussion
   - Follow-up of the steps Six sigma.
6. Conclusion After analysis and discussion
   - It can draw conclusions on Project Six sigma.

4. Results and Discussion

From the results of data retrieval Non Conformity during March 2016 to June 2016 in get data such as Table 2:

Table 2: Process Data of PT. XYZ (Mar - Jun 2016)

<table>
<thead>
<tr>
<th>Period type of NC</th>
<th>Mar’16 Qty</th>
<th>% Prod Result</th>
<th>Apr’16 Qty</th>
<th>% Prod Result</th>
<th>May’16 Qty</th>
<th>% Prod Result</th>
<th>Jun’16 Qty</th>
<th>% Prod Result</th>
<th>TOTAL Qty</th>
<th>% Prod Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coating NG</td>
<td>469</td>
<td>0.810%</td>
<td>605</td>
<td>0.895%</td>
<td>67,587</td>
<td>1.328%</td>
<td>62,189</td>
<td>2,588</td>
<td>251,582</td>
<td>62.189%</td>
</tr>
<tr>
<td>Marking NG</td>
<td>78</td>
<td>0.135%</td>
<td>101</td>
<td>0.149%</td>
<td>67,587</td>
<td>0.111%</td>
<td>62,189</td>
<td>332</td>
<td>251,582</td>
<td>62.189%</td>
</tr>
<tr>
<td>Mu Marking</td>
<td>70</td>
<td>0.121%</td>
<td>91</td>
<td>0.135%</td>
<td>67,587</td>
<td>0.092%</td>
<td>62,189</td>
<td>277</td>
<td>251,582</td>
<td>62.189%</td>
</tr>
<tr>
<td>Popo</td>
<td>55</td>
<td>0.095%</td>
<td>71</td>
<td>0.105%</td>
<td>67,587</td>
<td>0.092%</td>
<td>62,189</td>
<td>237</td>
<td>251,582</td>
<td>62.189%</td>
</tr>
</tbody>
</table>
Coating process shows the largest Non Conformity with Non Conformity detail as shown in table 3.

<table>
<thead>
<tr>
<th>Process</th>
<th>Item</th>
<th>Unit</th>
<th>Before Improvement</th>
<th>Mar '16</th>
<th>Apr '16</th>
<th>May '16</th>
<th>Jun '16</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assembling</td>
<td>Prod. Result (Input)</td>
<td>Kpcs</td>
<td>59,038</td>
<td>68,992</td>
<td>63,733</td>
<td>65,733</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Qty NC</td>
<td>Pcs</td>
<td>375</td>
<td>397</td>
<td>398</td>
<td>476</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Non Conformity</td>
<td>%</td>
<td>99.4</td>
<td>99.4</td>
<td>99.4</td>
<td>99.3</td>
<td></td>
</tr>
<tr>
<td>Coating</td>
<td>Prod. Result (Output)</td>
<td>Kpcs</td>
<td>58,663</td>
<td>68,595</td>
<td>63,336</td>
<td>64,907</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Qty NC</td>
<td>Pcs</td>
<td>779</td>
<td>1,004</td>
<td>1,145</td>
<td>985</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Non Conformity</td>
<td>%</td>
<td>98.7</td>
<td>98.5</td>
<td>98.2</td>
<td>98.5</td>
<td></td>
</tr>
<tr>
<td>Sorting</td>
<td>Prod. Result (Output)</td>
<td>Kpcs</td>
<td>57,882</td>
<td>67,587</td>
<td>62,189</td>
<td>63,924</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Qty NC</td>
<td>Pcs</td>
<td>388</td>
<td>378</td>
<td>277</td>
<td>392</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Non Conformity</td>
<td>%</td>
<td>99.3</td>
<td>99.4</td>
<td>99.6</td>
<td>99.4</td>
<td></td>
</tr>
<tr>
<td>Editing</td>
<td>Prod. Result (Output)</td>
<td>Kpcs</td>
<td>57,296</td>
<td>67,023</td>
<td>61,734</td>
<td>63,410</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Qty NC</td>
<td>Pcs</td>
<td>199</td>
<td>187</td>
<td>178</td>
<td>122</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Non Conformity</td>
<td>%</td>
<td>99.7</td>
<td>99.7</td>
<td>99.7</td>
<td>99.8</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>Good Ratio</td>
<td>%</td>
<td>97.04</td>
<td>97.0</td>
<td>96.86</td>
<td>96.97</td>
<td></td>
</tr>
</tbody>
</table>

From the data on the numbers can be Non Conformity in June 2016, which is shown with Pareto Graph below:

![Pareto Chart of Coating Process](image)

**Figure 1:** Pareto NC Coating Process

Furthermore, from the pareto data, we look for some of the causes of the largest non conformity in the coating process ie coating dents. Here is the cause and effect diagram of Dents Coating.
Figure 2. Causation diagram of Coating Dent

Table 4: Failure Mode and Effect Analysis

<table>
<thead>
<tr>
<th>No</th>
<th>Process/Step</th>
<th>Failure Mode</th>
<th>Cause Failure</th>
<th>Effect of Failure</th>
<th>OCC</th>
<th>SVN</th>
<th>DTC</th>
<th>RPN</th>
<th>Possible Cause</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Temperature</td>
<td>Setting</td>
<td>Temperature unstable</td>
<td>Coating NG, Gigong</td>
<td>5</td>
<td>8</td>
<td>3</td>
<td>120</td>
<td>- Broken TPR/TIC - Not homogenous Heat Circulation - Dirty Heater.</td>
</tr>
<tr>
<td></td>
<td>Machine speed</td>
<td>Setting</td>
<td>Indicator and Pulley problem (broken)</td>
<td>Marking NG, Mittnocul</td>
<td>2</td>
<td>8</td>
<td>3</td>
<td>48</td>
<td>- There isn’t display indicator (old model) - Not yet installation reels impulley (new model).</td>
</tr>
<tr>
<td></td>
<td>Setting Reservoir</td>
<td>Vacuum</td>
<td>Powder circulation not properly</td>
<td>Gipo</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>3</td>
<td>- Reservoir Indicator still analog. - Leakage of compressor.</td>
</tr>
<tr>
<td></td>
<td>Setting Marking</td>
<td>Marking NG</td>
<td>Censor Position, Jig or fixture of Censor and Time Delay</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Movement product</td>
<td>Sticky Coating</td>
<td>Broken Wheel, broken strain yarn and Product not handle properly by operator</td>
<td>Popo</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>3</td>
<td>- Old Wheel - Not stopper installation.</td>
</tr>
</tbody>
</table>

- Air heater installation.
- TIC Display in each air heater.
- Installation air pipe to blower.
- Cooling profile installation.
- Installation indicator of new model.
- Installation new pulley with reel.
- Reservoir Indicator still analog.
- Leakage of compressor.
- Double marking installation.
- Modification of fixture censer to make set up easier and faster.
- Issue SOP/Keypoint for time delay.
- Wheel modification.
- Installation stopper to make easier and faster of operator working.

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Based on data processing and through pareto diagrams, causation, FMEA and other supporting data for problem solving occurring in our Coating process can result in some continuously growing improvement to produce high-quality products.

In Figure 3 can be seen data changes that occur in the Coating process according with the company's vision to be number one in the world.

5. Conclusion

1) Six Sigma method to improve the quality of the product in PT. XYZ successfully implemented well
2) Improved quality with six sigma method through DMAIC (Define, Measure, Analyze, Improve, and Control):
   a) The decrease target of Defect Per Million Opportunities from 15,410 in June 2016 to 2.8 in December 2016.
   b) The achievement of the Defect Per Million Opportunity reduction targets according to the timetable is also supported by the establishment of a good team that not only focuses on the Quality Department but together with the Production, Technical and Maintenance Departments. With the support by Top Management.
   c) To analyze the cause of the above problem is done by using QC Tools in the form of cause and effect diagram then to determine the priority of improvement is done by using Failure Mode and Effect Analysis which improvement priority seen in Risk Priority Number. Improvements are preferred based on Non Conformity Product data, which are listed in the pareto chart. Improvements will continue to be sustainable in line with the company's priority and readiness levels in terms of funding, difficulty levels and preferably at the most influential priority level in order to improve the quality efficiently and efficiently. This is intended to continue to carry out continuous improvement so that in the end Zero Defect achieves in accordance with the company's mission.
3) With the non-conformity decline dramatically as in point 2.a then there is a significant decrease in Cost, which affects the improvement of the company's business as well as bringing a good reputation in the company and becomes a manufacturing company DCC and Varistor in

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