Proposed Improvement Product of Cake Pan Using The Six Sigma Method Approach (Case Study of PT. X)

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Abstract. PT. X is a manufacturing company that produces several cookware including Cake Pan. The total number of defects in Cake Pan for 3 months increased by a percentage of 0.384% of the total production of Cake Pan. The purpose of this study using the Six Sigma method is to identify and analyze proposals that can be given to control product quality in order to reduce defective products through the Six Sigma approach. This study found that the capability and sigma value of company performance in improving product quality amounted to 930.68 DPMO with a sigma value of 4.6. Based on the cause and effect diagram FMEA known causes of product defects are color defects, spiral defects, dent defects and hollow defects. Based on the results of the calculation of the RPN to determine the most critical and urgent focus priorities to be addressed, namely the quality of raw materials is not good to be the highest RPN value of 288 with a high severity level of 8. The proposals that can be given are in the form of worker SOPs and checking tables in the form of a system 5s. This research is expected to be useful for companies in providing input as well as an overview in the form of information to PT. X in giving more attention to product quality with several supporting factors that affect the quality of the product.

1. Introduction
Product problems that are often encountered at PT. X is often found with product defects in its production process. Defects in the product are caused by several factors that can cause the resulting product to become defective. The defect in question is not according to specifications that are usually produced. The characteristics of product defects that occur in some of its processes are that there are large holes in the surface of the cake pan, scratch, inaccurate brands, dents, uneven spirals, incompatible colors, and have small holes and broken lines on the product surface. Therefore, all products that do not meet specifications will be considered defective products and will not be distributed to consumers but will be reworked or defect line.

Table 1. Percentage of production data obtained from PT. X from May 2019 until July 2019.

| No | Month | Production | Defect | Percentage |
|----|-------|------------|--------|------------|
| 1  | May   | 258000     | 710    | 0.275%     |
| 2  | June  | 228969     | 1197   | 0.522%     |
| 3  | July  | 174283     | 1149   | 0.659%     |

Based on the data in Table 1, the total number of defective products and percentages from May to July 2019 has increased from the total production of Cake Pan.
1. Define (Diagram SIPOC, Critical to Quality)

The SIPOC (Supplier-Input-Process-Output-Customers) diagram can be seen in Figure 1.

2. Measure (Control P-Chart, DPMO, dan Sigma level)

Because the data obtained at PT. X is an attribute, then the control chart used is the P control chart. Result Calculation of Control P-Chart can be seen in Table 2.

| No  | Date      | Number of Defects | Production Amount | p      | P bar   | UCL  | LCL  |
|-----|-----------|-------------------|-------------------|--------|---------|------|------|
| 2   | 3-May-19  | 157               | 27302             | 0.00612| 0.00465| 0.00585| 0.00415|
| 5   | 7-May-19  | 20                | 5626              | 0.00395| 0.00465| 0.007371| 0.001929|
| 15  | 18-May-19 | 0                 | 751               | 0      | 0.00465| 0.010358| 0    |
| 20  | 24-May-19 | 78                | 17374             | 0.00448| 0.00465| 0.006198| 0.003102|
| 22  | 27-May-19 | 0                 | 1508              | 0      | 0.00465| 0.00574 | 0    |
| 23  | 28-May-19 | 0                 | 1956              | 0      | 0.00465| 0.00262| 3.766-05|
| 24  | 30-Jun-19 | 42                | 13380             | 0.00314| 0.00465| 0.006414| 0.002986|
| 25  | 11-Jun-19 | 75                | 15010             | 0.00495| 0.00465| 0.006516| 0.002964|
| 27  | 13-Jun-19 | 124               | 21362             | 0.00554| 0.00465| 0.006035| 0.00285 |
| 28  | 14-Jun-19 | 25                | 8872              | 0.00203| 0.00465| 0.006637| 0.002463|
| 29  | 15-Jun-19 | 37                | 7592              | 0.00487| 0.00465| 0.006652| 0.002306|
| 34  | 21-Jun-19 | 35                | 10405             | 0.00336| 0.00465| 0.006651| 0.001649|
| 37  | 25-Jun-19 | 24                | 6506              | 0.00206| 0.00465| 0.007161| 0.002119|
| 39  | 27-Jun-19 | 57                | 15660             | 0.00296| 0.00465| 0.006281| 0.001819|
| 41  | 29-Jun-19 | 80                | 12956             | 0.00463| 0.00465| 0.006448| 0.002857|
| 42  | 1-Jul-19  | 52                | 12168             | 0.00407| 0.00465| 0.00665 | 0.002986|
| 43  | 2-Jul-19  | 73                | 12450             | 0.00586| 0.00465| 0.006749| 0.002821|
| 49  | 9-Jul-19  | 30                | 10419             | 0.00238| 0.00465| 0.00665| 0.002856|
| 52  | 12-Jul-19 | 0                 | 119               | 0      | 0.00465| 0.02339 | 0    |
| 53  | 13-Jul-19 | 0                 | 480               | 0      | 0.00465| 0.019965| 0    |
| 54  | 15-Jul-19 | 0                 | 360               | 0      | 0.00465| 0.015407| 0    |
| 55  | 16-Jul-19 | 0                 | 628               | 0      | 0.00465| 0.012794| 0    |
| 56  | 18-Jul-19 | 0                 | 432               | 0      | 0.00465| 0.01447 | 0    |
| 61  | 25-Jul-19 | 0                 | 1527              | 0      | 0.00465| 0.008873| 0    |
| 62  | 26-Jul-19 | 5                 | 3229              | 0.00154| 0.00465| 0.006242| 0.001058|
| 66  | 31-Jul-19 | 18                | 3481              | 0.00517| 0.00465| 0.008109| 0.001151|
| TOTAL|           |                   | 9322              | 212652 |

Control chart is used to determine the quality characteristics of the production results which are stated to be at the control limit or not.
The following is a new graphic image as shown in Figure 4. Chart of Control Chart P Number of Defect Units.

From the p control chart image that has been plotted or stocked shown on the P Full Control chart, it appears that there are no data that are outside the statistical control limits, all the data in this process are both within the upper and lower control limits. From the observation of the control map p, the data in this process has been declared stable.

DPMO calculation

After ensuring that the Cake Pan production process is within the control limits, the DPMO and sigma level calculations are performed. DPMO is the number of defects per million possibilities, obtained by multiplying the number of defects by one million possibilities.

Table 3. Calculation of Sigma Value

| Step | Measure                              | Equation | Result        |
|------|--------------------------------------|----------|---------------|
| 1    | What productions do you want to know?| Cake Pan |               |
| 2    | How many units are inspected?         |          | 212,652.00    |
| 3    | How many products are defective?      |          | 922.00        |
| 4    | Calculate the product failure rate    | step 3/ step 2 | 0.0043357 |
| 5    | The number of potential CTQs that result in failure | The many characteristics of CTQ | 5 |
| 6    | Calculate the failure rate of CTQ or DPO characteristic products | step 4/ step 5 | 0.00086714 |
| 7    | Calculates the probability of a DPMO failure | step 6x1000.000,- | 867.14 |
| 8    | Conversion of DPMO into sigma Table  |          | 4.6           |
| 9    | Conclusion Sigma Compute Value        |          | 4.6           |

Information:

Convert DPMO into Six Sigma
Six Sigma = Normsinv ((1.000.000 -DPMO)/ 1.000.000) + 1.5 -- [Normsinv at Excel]

The DPMO value is 930.68. After the DPMO value is obtained, the sigma level obtained by looking at the six sigma table conversion is 4.6 (indicating that improvements are still needed to reduce the defects that arise, so the sigma level can increase at least close to 5 or 6).

3. Analyze(Pareto Diagram, Fishbone Diagram)

1. Pareto Diagram

Pareto Diagrams are made with the intention to be able to focus more attention on problems that often arise by ordering the existing problems so that later they are expected to be able to help in analyzing the causes of disability that are still far from what is expected.

In this case, the Pareto Diagram is intended to identify the most dominant types of defects that often arise in the process of making Cake Pan, so that later they can prioritize the problem. Data on the types of defects in making cookware can be seen in Table 4.
Table 4. Data on Percentage and Frequency of Cumulative Disability

| No | Type of Defect     | Frequency of Defect | Cumulative Frequency | Total Percentage % | Percentage Cumulative % |
|----|-------------------|---------------------|----------------------|-------------------|--------------------------|
| 1  | Spiral Defects   | 588                 | 588                  | 19%               | 19%                      |
| 2  | Color Defects    | 2120                | 2708                 | 69%               | 88%                      |
| 3  | Perforated Defects | 165                | 2873                 | 5%                | 94%                      |
| 4  | Scratch Defects  | 183                 | 3056                 | 6%                | 100%                     |

The following is a Pareto Diagram of defective data for the period May - July 2019 at PT. X can be seen in Figure 3.

![Pareto Diagram](image)

Figure 3 Pareto Diagram of defective data in the period May - July 2019

From the Pareto Diagram, the defect data for the period May - July 2019 clearly shows that the most defects occur are Color Defects (69%) followed by Spiral Defects (19%), Dented Defects (6%), then Perforated Defects (Perforated Defects (Perforated) 5%). Seeing the results of the most common defect problems, namely the Color Defect.

2. Cause and Effect Diagrams (Fishbone Diagrams)

After knowing the main priorities of the defects that occur in the Cake Pan process, the next step is to analyze in the form of a causal diagram. Cause and effect diagram is a diagram that shows the relationship between cause and effect. Cause and effect diagrams are used to show the causative factors (causes) and the effects caused by the factors of those causes (consequences). Based on the results of brainstorming conducted together with the head of production, the causes of color, spiral, hole, and dent defects were found. Cause and Effect diagram can be seen in Figure 4.

![Cause and Effect Diagram](image)

Figure 4 Cause and Effect Diagram
4. Improve (Failure Mode and Effect Analysis (FMEA))

In the next stage that is improve, this is done in steps to determine the corrective actions that will or can be done to reduce defects. In this stage, recommendations for improvement will be given according to the root cause of the defect.

Failure Mode and Effect Analysis (FMEA)

Based on the results of interviews from the company in the production department, data severity, occurrence, and detection are obtained. Then an analysis of the causes of defects from the cake pan manufacturing process has the highest product defects using Failure Mode and Effect Analysis (FMEA).

Table 5. Table FMEA

| No | Potential Failure Effects                        | Severity | Potential Cause                  | Type of Defects | Occurrence | Current Actions | Recommended Actions | Detection | RPN |
|----|-------------------------------------------------|----------|----------------------------------|-----------------|------------|-----------------|---------------------|-----------|-----|
| 1  | The quality of raw materials is not good         | 8        | The environment for storing moist and dirty raw materials | Color Defects   | 6          | Clean storage regularly | Implement the 5s system | 6         | 288 |
| 2  | Oven Less Heat                                  | 8        | Workers rush to put the product in the oven | Color Defects   | 5          | Retrained Workers | Give Warning to Workers to follow SOP | 6         | 240 |
| 3  | Lack of Knowledge of Machines                   | 6        | Lack of Training                  | Color Defects   | 6          | Hold Training     | Increase Productivity | 3         | 108 |
| 4  | Paint Contaminated With Dust                    | 7        | Dirty room                        | Color Defects   | 5          | Clean storage regularly | Implement the 5s system | 6         | 210 |
| 5  | Lack of Control During the Production Process   | 8        | Workers do it their own way       | Spinal Defects  | 7          | Retrained Workers | Providing Training and Warnings for Workers to follow SOP | 4         | 224 |
| 6  | Reduced Productivity                            | 5        | Engine Has Decreased Performance | Spinal Defects  | 3          | -                | Maintenance of production equipment and machinery on a Re-planning and completing production support facilities | 5         | 75  |
| 7  | There is a product defect in the spiral section | 8        | Worker’s Fatigue Factor at Work   | Spinal Defects  | 5          | -                | Improve Productivity | 3         | 120 |
| 8  | Product Sizes Do Not Comply with Standards      | 7        | Less Skilled Workers              | Spinal Defects  | 6          | Hold Training     | Improve Productivity | 3         | 126 |
| 9  | Carless Workers                                 | 5        | Employees are less careful         | Scratch Defects | 4          | Retrained Workers | Control the Worker | 7         | 140 |
| 10 | There is a hole in the Cake Pan                 | 8        | Product size that is not according to the standard in the spiral process | Perforated Defects | 6          | Retrained Workers for workers following standard product sizes | Give Warning to Workers to follow SOP | 3         | 144 |

5. Control

Based on the results of identification on the 4 types of defects that exist using FMEA and RPN calculations that have been done to determine the priority priorities that are the most critical and urgent to be handled, it is known that the quality of raw materials is not good due to the environment where the storage of damp and dirty raw materials becomes a value The highest RPN is 288 with a high severity level which is 8 then the second is Oven less heat caused by workers in a hurry to put the product into the oven with 240 RPN values and high severity value also that is 8 and the third highest RPN value is the lack of control over the machine is known because workers do their work in their own way with a RPN 224 and a severity 8.

Based on the results of the FMEA brainstorming with the company in the field of production that has been done, then the 3 highest RPNs were chosen with various proposals and then the proposed outputs were made to PT. X to do:

1. Compile and apply the 5s checklist

The number of workers with their respective duties - often being the part that is not fully controlled because there is no fixed control system. The proposed checklist 5s contains a list of things that must be checked and monitored for comfort, safety, and most importantly is an evaluation of the situation of the plant.

2. Develop and implement SOP training for workers.

In making operational standards, this procedure is expected to make workers more productive and effective. This SOP contains regulations and policies relating to work in each production process. So
that workers are expected to be more careful and more understanding of their work without having to feel rushed in doing their work.

3. **Arranging and implementing SOP of production communication system and production coordination in the company along with the punishment policy that will be received.**

In making standard operational procedures, it is hoped that workers will be more concerned and work better. The SOP that is made contains work steps that become the tasks and responsibilities of workers as a whole in detail, there are also sanctions or punishments to create a deterrent effect for workers who perform their work without following the procedures established by the company.

**CONCLUSION**

After conducting the existing DMAIC stages, the researchers reach the following conclusions:

1. There are four types of defects in PT. X are color defects, spiral defects, dent defects, and hollow defects with 69%, 19%, 6% and 5% of the total defect data respectively. Among the four types of defects that exist, color defects are the most common defects in the production process of making Cake Pan.

2. In the results of observations on the P control map, all data in the process are within the upper and lower control limits, so that the data in the process have been declared stable.

3. There are 3 proposed improvements made based on the discussion of cause analysis and defect factors in the FMEA table at PT. X to reduce defects in Cake Pan products in accordance with the largest RPN value, namely the problem of poor raw material quality, oven that less heat caused by workers in a hurry, as well as lack of control over the machine due to workers doing their work in their own way.

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