Quality Control Analysis on Poly cups Products Using Six Sigma Approach at PT “X”

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Abstract. Quality in the manufacturing industry besides emphasize on the products produced, also need to be considered quality in the production process. Thus, the final product is defect free and there is no more waste to be paid handsomely because the product must discarded or reworked. PT. “X” is a company in the form of a Limited Liability Company in Deli Serdang Regency, North Sumatra. This limited liability company was established by several. PT. “X” is engaged in manufacturing namely producing poly cups. This company can produce 3900 poly cups box cartons / day. In a day can produce 352,800 poly cups / day. This quality control research was conducted at PT "X" with the product produced was poly cup. The study was conducted to determine the attribute defect of the poly cups with poly cups divided into 23 subgroups. Sampling is done by systematic sampling. Then, Six Sigma is one of the approaches that is used in this company quality control such as another make to stock company type.

1. Introduction

The quality of a product is one of the keys to the progress and success of a company. Appropriate and fundamental changes occur in life in all fields require freedom of interaction between life in the world without knowing national borders, including in trade and business activities. Companies that maintain the quality of the product will be more beneficial for reducing production costs and will be successful in marketing and accepted by consumers and will ultimately increase profits for the companies that produce it. The purpose of holding quality control is to provide a new tool that makes the inspection process more effective. On the off chance that the consequences of QC tests can't satisfy the acknowledgment models, the aftereffects of examination of the entire arrangement of the estimations on that day must be eliminated or should be re-dissected, and an incomplete or full re-approval of the strategy considered [11].

PT. “X” is a company in the form of a Limited Liability Company in Deli Serdang Regency, North Sumatra. This limited liability company was established by several. PT. “X” is engaged in manufacturing namely producing poly cups. This company has direct workers ± 49 people. The material used by PT. “X” to make poly cups divided into raw materials, auxiliaries, and additives. Raw materials are the main ingredients used in the production process to produce a product. The raw material used in making this poly cups product is plastic ore (polypropylene). Plastic ore is a material obtained from local and imported. Auxiliary materials are materials used in the production process, which are only helping or supporting the continuity of the production process to get the desired product and are not included in the final product. The supporting material used by PT. “X” is water
only. Additional ingredients are ingredients that will be mixed with the main ingredients that can change the characteristics of the product. Additional ingredients used are Carton box, used as a place to package poly cups before selling to consumers, plastic bags, used to place poly cups in small quantities, and Opp tape, used to tie a nail box that contains nails.

Machines - production machines used by PT."X" are extruder machine used to mix raw materials, moulder machines used as poly cups printers, and roker machine used to re-grind products that are not according to specifications / defective products. The description of the production process in the manufacture of poly cups products can be seen in the following flow chart.

![Poly cups manufacturing flow chart](image)

**Figure 1.** Poly cups manufacturing flow chart

This company can produce 3900 poly cups box cartons / day. In a day can produce 352,800 poly cups / day. The raw material inventory system in this company is make to stock, which is to provide raw materials before supplies run out.

This quality control research was conducted at PT "X" with the product produced was poly cups. The study was conducted to determine the attribute defect of the poly cups with poly cups divided into 23 subgroups. Sampling is done by systematic sampling.

2. **Theoretical Background**

2.1. **Definition of Quality**

Quality is the totality of the characteristics of a product which supports his ability to satisfy the requirements specified or applied. Quality is defined as the totality of characteristics of a product that supports its ability to satisfy needs specified or specified. The quality of a product is one of the keys to the progress and success of a company. Appropriate and fundamental changes occur in life in all fields that require freedom of interaction between life in the world without knowing national borders, including in trade and business activities. Companies that maintain the quality of the product will be
more beneficial for reducing production costs and will be successful in marketing and accepted by consumers and will ultimately increase profits for the companies that produce it. The purpose of holding quality control is to provide a new tool that makes the inspection process more effective [1].

2.2. Quality Control
Quality assurance principles apply both to goods produced by factories and services. The aim is to present the technical tools needed to achieve quality assurance in goods and services producing organizations. It is essential that the product meets the requirements of the people who use it. Therefore, the definition of quality is the quality of money means the compatibility of its use. There are two general aspects of quality: quality of design and quality of compatibility. This variation in level of quality is intentional, therefore the appropriate technical term is design quality. Compliance quality is as good as the product according to the specifications and leeway required by the design. The quality of compatibility is influenced by many factors, including the selection of the manufacturing process, training and supervision of the workforce, the type of quality assurance system (process control, testing, inspection activities, etc.) that is used, how far these quality assurance procedures are followed, and motivation of the workforce to reach quality. Quality control is an engineering and management activity, by which we measure the characteristics of product quality, compare them with specifications or requirements, and take appropriate sanitary measures if there is a difference between the actual appearance and the standard [2].

2.3. Determination of Sample Amount and Systematic Sampling
Basically, taking the number of samples depends on the condition of the population. If the population is very homogeneous, then sampling is sufficient. However, if the population conditions are very heterogeneous, then the sampling must consider that each level of the population must be represented. It should be noted that sampling must exceed the number of variables that will be followed in the population.[3]

Systematic sampling is a method of taking a sample of a population by pulling elements of each n multiple of the population starting from a randomly selected sequence between numbers 1 till n. For example, a sample of size 25 will be drawn from a population of size 250. The elements in population are numbered 1 to 250, if the sample size is compared to the population size for example there are 6 multiples. Systematic sampling methods are generally used in quality checks of processes or products in the manufacturing industry that are continuous and flow process such as the oil refining industry, the cement industry, fertilizers, and the like. While the process is running, materials and products flow continuously, the sample needs to be taken periodically within a certain time interval. For example, the process lasts 24 hours a day and 48 samples are needed for inspection of samples, then withdrawal is done every half hour.[4]

2.4. Six Sigma Approach
The measure of failure in Six Sigma that shows failure per million opportunities is called Defects Per Million Opportunities (DPMO). The target of controlling Six Sigma is 3.4 DPMO. DPMO indicates how many errors will occur if an activity is repeated a million times [5]. The Six Sigma team in completing specific projects to reach the Six Sigma level needs to be guided by the 5 phases of the DMAIC. This concept is used for process improvement projects with Six Sigma carried out by implementing five steps called DMAIC (Define-Measure- Analyse -Improve-Control) as follows:

2.4.1. Define (D). The Define Phase is the first operational step in the Six Sigma quality improvement program. In the Define phase, identifying potential projects, defining the roles of people involved in Six Sigma projects, identifying key quality characteristics (CTQ) that are directly related to the specific needs of customers and determining goals. The define stage can be explained by project charter, SIPOC diagram and determination of CTQ values.
2.4.2. Measure (M). Measure is the second operational step in the Six Sigma quality improvement program. Measure in six sigma is a statistical tool and in the form of DPMO calculations and sigma values to measure work baselines with pareto diagrams. How to determine DPMO and sigma level are as follows:

- Calculate Defect per Unit (DPU)
  \[
  DPU = \frac{\text{Total Defective Product}}{\text{Total Production}}
  \]  
  (1)

- Calculate Defect per Opportunity (DPO) which is failure by one chance.
  \[
  DPO = \frac{DPO}{CTQ}
  \]  
  (2)

- Calculate sigma level, sigma level can be easily calculated by Microsoft Excel using the formula as follows:
  \[
  \text{Sigma level} = \text{NORMSINV} \left( \frac{1 - \text{DPMO} / 1,000,000}{1.5} \right) + 1.5
  \]  
  (3)

2.4.3. Analyse (A). The analyse phase is the phase in which identification, organization and validation of the root causes of potential problems are carried out. At this stage the root cause of the key CTQ is determined by using a causal diagram (fishbone) tool.

2.4.4. Improve (I). In this step an action plan is implemented to improve the quality of Six Sigma. The plan describes the allocation of resources as well as priorities or alternatives taken. One of them is by using the FMEA method to identify and prioritize potential problems (failure).

2.4.5. Control (C). It is the last operational stage in the Six Sigma quality improvement project. At this stage quality improvement procedures and results are documented as standard work guidelines to prevent the same problem or old practices from reoccurring the proposed improvements can be made certain and run well, it is important to create a working procedure that arrange operators, machines, and methods in the process of working. [6]

3. Method
Production data and production defects data of PT "X" is production data and production defect from January to December 2016. Types of data used, namely primary and secondary data. Types of defects in poly cups products are melted (M), perforated (P), and dented (D). Then, the number of samples for control chart in this study is assumed to be 405 units which is divided into 23 subgroups and use systematic sampling. The following is a problem-solving flow chart of the research conducted:
4. Results and Discussion

4.1. Define (D)
From production data and defect data PT”X” made, obtained data for the number of production and product defects can be seen in Table 1.
Tabel 1. Production dan defect data

| No | Month     | Total Production | Total Defect |
|----|-----------|------------------|--------------|
| 1  | January   | 10984605         | 87877        |
| 2  | February  | 11030780         | 88246        |
| 3  | Maret     | 11204560         | 89636        |
| 4  | April     | 11212750         | 89702        |
| 5  | May       | 10563645         | 92509        |
| 6  | June      | 9341970          | 74736        |
| 7  | July      | 9953240          | 79626        |
| 8  | August    | 10640850         | 85127        |
| 9  | September | 11275040         | 90200        |
| 10 | Oktober   | 11345255         | 90762        |
| 11 | November  | 11055230         | 88442        |
| 12 | Desember  | 10200445         | 81604        |
|    | Total     | 128808370        | 1038467      |

From observations of 405 units sample made, obtained data for the number of product defects can be seen in Table 2.

Table 2. Stratification of the amount of defective products

| Sub Group | Number of Inspection | Number of Nonconforming | Number of Nonconformities | Melted (M) | Perforated (P) | Dented (D) | Total |
|-----------|---------------------|-------------------------|---------------------------|------------|----------------|------------|-------|
| 1         | 15                  | 1                       | 4P                        | -          | -              | I          | 1     |
| 2         | 20                  | 2                       | 13P, 13B, 20S, 20B        | I          | II             | I          | 4     |
| 3         | 15                  | 2                       | 1P, 13B                   | -          | I              | I          | 2     |
| 4         | 15                  | 2                       | 12P, 14S                  | -          | I              | I          | 2     |
| 5         | 20                  | 4                       | 5P, 12P, 12B, 13P         | -          | I              | III        | 5     |
| 6         | 20                  | 3                       | 6S, 11P, 13B, 13P         | I          | I              | II         | 4     |
| 7         | 15                  | 2                       | 4P, 5S                    | I          | -              | I          | 2     |
| 8         | 20                  | 1                       | 4S, 4B                    | I          | I              | -          | 2     |
| 9         | 20                  | 2                       | 2B, 2P, 4S, 4P, 4B        | I          | II             | II         | 5     |
| 10        | 15                  | 1                       | 7P                        | -          | -              | I          | 1     |
| 11        | 15                  | 2                       | 5S, 5B, 14P, 14B          | I          | II             | I          | 4     |
| 12        | 20                  | 1                       | 19S, 19P                  | I          | -              | I          | 2     |
| 13        | 20                  | 1                       | 15S, 15P, 15B             | I          | I              | I          | 3     |
| 14        | 15                  | -                       | -                         | -          | -              | -          | -     |
| 15        | 15                  | 1                       | 5S, 5P, 5B                | I          | I              | I          | 3     |
| 16        | 20                  | -                       | -                         | -          | -              | -          | -     |
| 17        | 15                  | 3                       | 3P, 3B, 4S, 4P, 15B       | I          | II             | II         | 5     |
| 18        | 15                  | -                       | -                         | -          | -              | -          | -     |
| 19        | 20                  | 1                       | 13S, 13P                  | I          | -              | I          | 2     |
| 20        | 15                  | -                       | -                         | -          | -              | -          | -     |
| 21        | 20                  | 1                       | 12B                       | -          | I              | -          | 1     |
| 22        | 20                  | 2                       | 1P, 16B                   | -          | I              | I          | 2     |
| 23        | 20                  | -                       | -                         | -          | -              | -          | -     |
4.2. Measure (M)

4.2.1. P Chart. This chart illustrates the part that was rejected because it did not meet the desired specifications. The following is a P Chart of 405 sample units in 23 subgroups.

![P Chart](image)

All data in 23 subgroups are already in control on P Chart.

4.2.2. U Chart. This chart illustrates the real mismatch in one sample unit and can be used for non-constant sample sizes.

![U Chart](image)

All data in 23 subgroups are already in control on U Chart.

4.2.3. Histogram. A histogram is a bar chart that shows tabulations of data arranged according to size. A histogram for the number of defective products c and its stratification can be seen in Figure 5 and 6.

![Histogram](image)

Figure 3. P chart

Figure 4. U chart

Figure 5. Number of defective products
4.2.4. Pareto Diagram. Pareto diagrams are made to find or find out the problem or cause that is the key in solving problems and the comparison of the whole. By knowing the dominant causes, we will be able to set priorities for improvement.[7]

4.2.5. Calculation of Six Sigma Values Pareto Diagram. The measure of failure in Six Sigma that shows failure per million opportunities is called Defects Per Million Opportunities (DPMO). The target of controlling Six Sigma is 3.4 DPMO. DPMO indicates how many errors will occur if an activity is repeated a million times. Determination of the six sigma value using the sigma calculator. Here are the six sigma calculation values. [8]
4.3. Analyze (A)

Based on observations on the production floor of the poly cups manufacturing process, there are several main factors causing defects made in the Why-Why table. In the Why-Why table are grouped into man, machine, and material factors. Then it will be analyzed to make a Failure Mode Effect Analysis (FMEA). The FMEA implementation began with observing the work process in the production system, identifying work safety risks, carrying out an analysis of the work safety risks that have been found, and making recommendations to take control measures [9].

| Defect   | Why     | Why                          | Why                          |
|----------|---------|------------------------------|------------------------------|
| Dented   | Man     | Operators do not understand  | The operator lacks experience |
|          |         | the signs on the machine     |                              |
|          | Material| The quality of raw materials is not good | Not the best brand         |  
|          | Machine | Damage on the engine         | There is no routine maintenance |

| Defect   | Why     | Why                          | Why                          |
|----------|---------|------------------------------|------------------------------|
| Melted   | Man     | Operators do not understand  | The operator lacks experience |
|          |         | the signs on the machine     |                              |
|          | Material| The quality of raw materials is not good | Not the best brand         |  
|          | Machine | Damage on the engine         | The operator lacks experience |

| Defect   | Why     | Why                          | Why                          |
|----------|---------|------------------------------|------------------------------|
| Perforated | Man   | Operators do not understand  | The operator lacks experience |
|           |         | the signs on the machine     |                              |
|           | Material| The quality of raw materials is not good | Not the best brand         |  
|           | Machine | Damage on the engine         | The operator lacks experience |

Table 3. Why-why table

| Main Factor Category | Description                                      |
|----------------------|--------------------------------------------------|
| Man                  | Matters relating to the experience and skills of workers |
| Material             | Matters relating to raw materials               |
| Machine              | Matters relating to maintenance and use of the machine. |
Then the problem is formed into the fishbone diagram as follows

**Figure 9.** Fishbone diagram of dented

**Figure 10.** Fishbone diagram of melted
Then, here is the problem-solving priority value for poly cups defect using FMEA

**Table 5. Problem solving priority value for poly cups defect**

| Part / Process Function | Potential Failure Mode | Potential Effect of failure | Severity | Potential Causes/ Mechanism Failure | Occurrence | Current Design Controls | Detection |
|-------------------------|------------------------|----------------------------|----------|-------------------------------------|------------|-------------------------|-----------|
| Man                     | Operators do not understan d the sign on the machine | Results not up to standard (Defect) | 2        | The operator lacks experience       | 3          | Provide training       | 5         |
|                         |                        |                            |          |                                     |            | Supervise the operator when working | 30        |
|                         |                        |                            |          |                                     |            | Provide training to add experience | 5         |
| Machine                 | Damage to the engine   | Results not up to standard (Defect) | 5        | Lack of engine maintenance          | 5          | Perform routine checks on the machine | 2         |
|                         |                        |                            |          |                                     |            | Check the machine before using it | 50        |
|                         |                        |                            |          |                                     |            | Perform regular machine maintenance | 5         |
| Material                | The quality of raw materials is not good | The resulting poly cups is easily damaged | 4        | Not from the best brand              | 3          | Ensuring good quality raw materials | 3         |
|                         |                        |                            |          |                                     |            | Check the quality of raw materials before processing | 36        |
|                         |                        |                            |          |                                     |            | More thorough in inspecting raw materials | 5         |

From Table 5 can be seen the highest RPN value that is found on the machine with a value of 50. Therefore, the first improvement is made on the machine. After that, it is followed by improvement of material and man.
4.4. Improve (I)

In the improve section, improvements are made using the 5w + 1H method. In this method, sentences are classified into multi-label whether it contains 5W + 1H (What, Who, Where, When, Why, and/or How) or nothing else by using training data that has been built. Sentences containing 5W + 1H will be selected as summary sentences. Here is the improvement action with the 5w + 1H method [10].

Table 6. Corrective action with 5W + 1H method

| What | Where | Why | Who | When | How |
|------|-------|-----|-----|------|-----|
| Improving the Worker's Ability to Use Machines | Production floor | So Operators Can Reduce Defect | Head of Production & Head of Training | Done for one to two months | Provide rigorous routine training and selection |
| | | Performed in the warehouse of raw materials to get the Desired Production Results | | | |
| Raw Material Inspection | | To get the Desired Production Results | Quality Control | Every Raw Material Entered | Perform regular inspections before the material is processed |
| Operator Supervision | Production floor | To Improve Discipline | Supervisor | During the Production Process | By supervising the performance of each operator in their fields |
| Operator Security | Production floor | To Prevent Accidents and Maintain Stamina / Physical Condition of Workers | Head of Production | During the Production Process | By Providing Training with the Importance of PPE for Operators |
| Improve Work Methods | Production floor | To get more satisfying production results and improved performance | Head of Production | Do every 1 month | Provide evaluation |
| Increasing the Number of Employees | Production floor | To Focus Operators Working on Each Part So Reducing Defect | Assistant Manager | When the Machine Is Idle (No Operator) | Recruitment |

4.5. Control (I)

Control is the phase of controlling process performance (x) and ensuring defects do not reappear. The tools commonly used are control charts. The general functions of control charts are, as follows:

- Help reduce variability
- Monitor performance at all times
- Allows the correction process to prevent rejection

Therefore, the Standard Operating Procedures (SOP) was needed and made based on FMEA and 5W + 1H methods in the improvement section.

5. Conclusion

Based on the results and discussion conducted above, it can be concluded that the sampling technique used was systematic random sampling used when measuring and checking the defect on poly cups products. In the define phase, it is found that the main factors that affect the defects are human, material, and machine and the types of defects found in the poly cups are dented, melted and perforated. In the measure phase, obtained the level of defect from poly cups products and revised the data out of control, but there is no out of control data on p chart dan u chart and also the six sigma
level value rare good 3,91. In the analyze phase, the attributes obtained are causes that can produce defects from poly cups products, namely humans, materials and machines. In the improve phase, the parameters of improvement in accordance with the priority is to treat the machine regularly to reduce the level of product defects. In the control phase, the tools used are Standard Operating Procedures (SOP).

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