Quality Control of Chopsticks Product Using Lean Six Sigma Approach Method

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Abstract. Quality control is carried out in order to produce products in the form of goods or services in accordance with the standards desired and planned. PT. XYZ is a manufacturing company that produces chopsticks made from bamboo. In producing chopstick products, PT. XYZ is experiencing waste problem, which is the number of defective products. The percentage of product defects experienced by the company is around 3%. Therefor, the six sigma approach method is used in an effort to improve product quality through the DMAIC stage (Define, Measure, Analyze, Improve, Control). In the define phase, 3 types of defects are found, which are perforated, broken and stringy. In the measure phase, the value of DPO is 0,153. In the analyze phase, the main factors causing defect are material due to the usage of low quality materials. In the improve phase, the 5W + 1H method is used to create a new method in reducing defects. In the control phase, a new SOP (Standard Operating Procedure) is made for the company.

1. Introduction
Quality is a relative term that is very dependent on the situation. Viewed from the view of consumers, subjectively people define quality is something that suits the taste (fitness for use). The product is said to be of quality if the product has a suitable use for itself [1]. Quality control is one technique that needs to be done starting from before the production process runs, at the time of the production process, until the production process ends with producing the final product. 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]. Quality control is carried out in order to produce products in the form of goods or services that are in accordance with the desired and planned standards, and improve product quality that is not in accordance with established standards and as much as possible maintain the appropriate quality [2].

PT. XYZ is a company that produces products made from bamboo. One of the products produced by this company is bamboo chopsticks. In producing chopstick products, PT. XYZ is experiencing waste problems, namely the number of defect products in the form of perforated, broken and stringy. The company’s maximum defect tolerance is 2%. The percentage of product defects experienced by the company is around 3%. Data on the number and percentage of chopstick defects can be seen in the following table.
Table 1. Total defects of chopstick products in the company

| Month    | Production Volume | Number of Defects | Defect Percentage (%) |
|----------|-------------------|-------------------|-----------------------|
| January  | 142981            | 2638              | 1.85                  |
| February | 145888            | 6263              | 4.29                  |
| March    | 142461            | 2051              | 1.44                  |
| April    | 142769            | 6469              | 4.53                  |
| May      | 142960            | 5980              | 4.18                  |
| June     | 145626            | 3464              | 2.38                  |
| July     | 143499            | 2256              | 1.57                  |
| August   | 143039            | 3190              | 2.23                  |
| September| 145559            | 6185              | 4.25                  |
| October  | 145564            | 2594              | 1.78                  |
| November | 145194            | 5531              | 3.81                  |
| December | 144018            | 4454              | 3.09                  |
| Total    | 1729558           | 51075             | 2.96                  |

Based on the data above, it is shown that the percentage level of chopstick defect is 2.96% in which it is above the company’s maximum defect tolerance which is 2%. For this reason, an improvement is needed due to the defect of this product to increase company productivity. One method that can be used to overcome this problem is to use the Six Sigma approach. The focus of Six Sigma is to reduce variability in key product quality characteristics at the level where failure or defects are highly unlikely. The Motorola Six Sigma concept is to reduce variability in the process so that the specification limits at least six standard deviations from the average [3]. In quality control, seven tools that are commonly used are as the follows [4]:

- Checksheet
- Stratification
- Control Chart
- Histogram
- Scatter Diagram
- Pareto Diagram
- Cause and effect diagram

The purpose of this research is to solve the chopstick product defect problem at PT. XYZ by using the Lean Six Sigma approach so that companies can reduce the percentage level of product defects and increase company productivity.

2. Methodology

2.1. Research Object
The research object used was the Chopsticks product. The Chopsticks will be inspected for the number of defective products and the number of defects found in each product unit in the form of defects such as broken, stringy, and perforated.

2.2. Research Data
The data used are primary data obtained from the measurement of length and diameter and defects in the product by using a measuring instrument in the form of a 30 cm ruler and a digital caliper.
2.3. Data Collecting

2.3.1. Sampling Technique. For the data collection stage of a study, a sampling process is needed on the data needed. There are two methods of sampling techniques that are commonly used in a study, namely the probabilistic method and non-probabilistic method. In a survey, it is not always necessary to examine all individuals in the population, because besides requiring a very large cost also requires a long time. In this research, the sampling techniques that will be used in data collection are stratified random sampling and simple random sampling [5].

2.3.2. Data Collecting Stage. Primary data is collected based on the results of research on the object of research with work procedures that have been carried out when conducting research. The data taken is in the form of dimensions of length and diameter of the surface of the chopsticks product, and defects in the product. The work procedures carried out when conducting research are divided into 3 stages. The first stage of measurement is carried out by 3 operators with the same object 2 times the measurement. The second stage measures the length and diameter of the same object 1 time. Then the third step takes measurements 20 times in the first dimension with simple random sampling.

2.4. Data Processing

Data processing in this study was carried out in accordance with the method to be used in this module, namely by using the DMAIC method (Define, Measure, Analyze, Improve, Control) as well as using Seven Tools in its processing. In the define step, identification of product defects and determination of the type of attribute and variable defects in the product will be carried out. The tools used in this step are the data checking and stratification sheets. In the measure step, a control chart is created that aims to show a comparison between the number of defects and all observations. In the analyze step, the tools used are histograms, pareto diagrams, scatter diagrams, and cause and effect diagrams to determine the main factors causing product defects. In the improve step, an evaluation is carried out to determine the right step in dealing with defects that occur using the 5W + 1H method. In the control step, a new SOP is made for the company to reduce the level of product defects.

3. Result and Discussion

3.1. Result

3.1.1. Input. Input is consisting of production disability data from the company and attribute and variable defect data. Working procedure in collecting data attribute of chopsticks products is based on 3 product defects (broken, stringy, perforated), namely:

- Data collection using Stratified Random Sampling method.
- The number of samples taken was 150 data.
- Products are divided into 15 sub group, where each sub group consists of 10 products.
- Defects from the product were observed in each sub group
- Fill in the table of the number of defective products.

3.1.2. Process. Lean Six Sigma uses statistical tools to identify several vital factors, the DMAIC Cycle is a key process for continuous improvement towards Six Sigma targets. DMAIC is carried out systematically based on science and facts (systematic, scientific, and fact based). DMAIC consists of the following steps: Define, Measure, Analyze, Improve, and Control [6].

3.1.3. Output. The output of quality control with this six sigma approach is to find out the causes of product defects and create a new Standard Operational Procedure (SOP).
3.2. Discussion

3.2.1. Define. The first step is to stratify the number of product defects using an examination sheet and data stratification

| Sub Group | Number of Inspection | Frequency | Number of Nonconforming | Information |
|-----------|----------------------|-----------|--------------------------|-------------|
| 1         | 10                   |           | 1                        | 3           |
| 2         | 10                   |           | 2                        | 9,10        |
| 3         | 10                   |           | 1                        | 5           |
| 4         | 10                   |           | 2                        | 2,8         |
| 5         | 10                   |           | 1                        | 1           |
| 6         | 10                   |           | 2                        | 2,5         |
| 7         | 10                   |           | 1                        | 4           |
| 8         | 10                   |           | 2                        | 2,9         |
| 9         | 10                   |           | 1                        | 2           |
| 10        | 10                   |           | 2                        | 4,5         |
| 11        | 10                   |           | 1                        | 3           |
| 12        | 10                   |           | 2                        | 6,9         |
| 13        | 10                   |           | 2                        | 1,2         |
| 14        | 10                   |           | 1                        | 1           |
| 15        | 10                   |           | 2                        | 9,10        |

Table 2. Defective products check sheet

3.2.2. Measure. The second step is the measurements made using the np control map. The np map represents a map that shows the difference between all protected and all observations. This map can be

| Sub Group | Number of Inspection | Broken | Stringy | Perforated | Machine | Material | Method | Man | Total |
|-----------|----------------------|--------|---------|------------|---------|----------|--------|-----|-------|
| 1         | 10                   | -      | 1       | -          | 1       | -        | -      | -   | 1     |
| 2         | 10                   | 1      | -       | 1          | -       | 1        | -      | 1   | 2     |
| 3         | 10                   | -      | -       | 1          | -       | 1        | -      | -   | 2     |
| 4         | 10                   | 1      | 1       | 1          | 2       | 1        | -      | 1   | 4     |
| 5         | 10                   | 1      | 1       | -          | 1       | -        | -      | -   | 2     |
| 6         | 10                   | -      | -       | 1          | 1       | 1        | -      | -   | 2     |
| 7         | 10                   | 1      | -       | 1          | -       | 1        | -      | -   | 2     |
| 8         | 10                   | 2      | 1       | -          | 1       | -        | -      | -   | 3     |
| 9         | 10                   | -      | -       | 1          | -       | 1        | -      | -   | 1     |
| 10        | 10                   | 1      | 2       | 1          | 2       | 1        | -      | 1   | 4     |
| 11        | 10                   | 1      | -       | -          | -       | -        | -      | -   | 1     |
| 12        | 10                   | -      | 1       | 1          | 1       | 1        | -      | -   | 2     |
| 13        | 10                   | 2      | 1       | 1          | 1       | 2        | -      | -   | 5     |
| 14        | 10                   | 1      | -       | 1          | -       | 1        | -      | -   | 2     |
| 15        | 10                   | 1      | 1       | 2          | 1       | 2        | -      | -   | 4     |

Table 3. Defective product stratification and causes of defects.
used for quality characteristics which can be seen only by attributes. By using the amount of data that
does not match each subgroup, a meaningful value is obtained as follows:
\[
\bar{p} = \frac{\sum n_p}{\sum n} = \frac{23}{150} = 0,1533
\]
\[
\bar{n}p = \frac{n \sum n_p}{\sum n} = \frac{10 \times 23}{150} = 1,5333
\]
Upper Class Limit (UCL) dan Lower Class Limit (LCL) can be calculated such as below:
\[
UCL = \bar{n}p + 3[\bar{n}p (1- \bar{p})]^{1/2}
\]
\[
LCL = \bar{n}p - 3[\bar{n}p (1- \bar{p})]^{1/2}
\]
UCL and LCL calculation result are as follows:
UCL = 4,9515
LCL = -1,8849 ≈ 0
Then, use the Minitab software to view the np map graph.

![np chart Graph](image)

**Figure 1.** np chart Graph

It can be seen on the map that there is no data that is outside the control limits (out of control) on the np
map. Therefore, there is no need for revisions. After that, proceed with the calculation of defects per
opportunity with the following formula.

\[
DPO = \frac{\sum n_p}{\sum n}
\]

Based on the DPO calculation, the DPO value is 0.1533. This shows that in a month's production there
are 15.33% defective chopsticks.

3.2.3. **Analyze.** A histogram is a bar chart that shows tabulations of data arranged according to size. Histogram data is taken from data number of nonconforming [7].
The function of the Pareto diagram is to identify the main problems for quality improvement from the largest to the smallest [8]. The results of making Pareto diagrams using Minitab software can be seen below.

In the Pareto diagram, the 80/20 rule applies, which means that 20% of the types of defects can cause 80% of process failures. From the diagram above it can be seen that the cumulative percentage for the perforated defect is below 80%, meaning that the perforated defect problem needs to be resolved. Next, a defects scatter diagram will be made using the Minitab software because the disability has the highest frequency of defect.
Cause and effect diagrams show the relationship between the problems faced with the possible causes and the factors that influence it [9].

FMEA is a tool used in identifying and assessing risks associated with potential failures. In solving existing problems, determined by calculating the priority risk value which is the multiplication between the value of the severity, occurrence, and detection [10]. Using the FMEA tool, we can calculate the number of RPNs for single defects: $96 + 200 + 336 + 192 = 824$. Because the number of RPNs is less than 1000, it can be concluded that the defects that occur are disturbing, and must be improved.

3.2.4. Improve. Generally, the specifications of the consumer of the Chopsticks industry in Indonesia do not require that the product is defect free. However, consumers provide leeway; i.e., defects that do not affect the function of the product are allowed because consumers realize how difficult it is to produce flawless products in the chopsticks industry, given the many factors that play a role in the production
process despite the tendency of high levels of human error. Based on the above thinking, the improvements made are only continuous. The method used in the improve stage is the 5W + 1H method.

**Table 4. Improving activity with 5W+1H method**

| Cause Factor | Causes                      | Who             | When                      | How                                      |
|--------------|-----------------------------|-----------------|---------------------------|------------------------------------------|
| Material     | Using low quality material  | Operator        | During production process | Choosing best quality material            |
| Man          | Lack of accuracy in work    | Operator        |                          | Schedule work hours according to production needs with the number of workers |
| Perforated   | Method used is not in accordance with operation rules | HRD & Head of Production |                          | Adjust the method used with the Indonesian National Standard (SNI) |
| Production Floor | Method & Machine | Broken machine part & Maintenance Expert | Replace damaged engine parts and make a maintenance schedule |

3.2.5. **Control.** The steps taken at this stage of control are making SOP. SOP (Standard Operational Procedure) is a written standard that is used to encourage and move a group to achieve certain goals.

4. **Conclusion**

There are three types of defect that occur during the chopsticks production process such as broken, stringy, and perforated. By using the Lean Six Sigma approach in this study, we are able to detect the quality problem that occurs at the company. The result of this study is to establish a new Standard Operational Procedure (SOP) in order to improve the quality of the product and produce less defective products. The new SOP is established based on the data of the root cause that occurs before the development of the new SOP. There are new ways in term of reducing defective products such as in terms of material factor, company should choose the best quality raw materials. In terms of man factor, company should make a work hour schedule according to the production needs with the number of workers to avoid causing fatigue on operator that may cause lack of accuracy during work. In terms of method factor, company should adjust the work method with the Indonesian National Standard to adjust with the operation rule. In terms of machine factor, company should make a maintenance schedule in order to minimize the broken part of the production machine.

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