Quality control of cutter case at PT. X with six sigma approach

Nurhayati Sembiring and Jeanica Devany*
Department of Industrial Engineering, Faculty of Engineering, Universitas Sumatera Utara

*E-mail: jeanicadevany2000@gmail.com, nurhayatipandia68@usu.ac.id

Abstract. Quality control is a system of maintaining the quality of products on an ongoing basis. In the industrial world, quality control is essential to meet customer demand. The problem formulated in this study is the assessment of the Defect of the Cutter Case produced by PT. The object in this study is the Cutter Case product. The number of samples used was 450 units. The Cutter Case will be inspected for the number of defective products and defect criteria that are met for each product unit, and the length and width of the product surface. Rules for the type of defect studied were melting, non-jagging, and bent. The method used in solving problems in this study is the Six Sigma method, namely DMAIC (Define, Measure, Analyse, Improve, Control).

1. Introduction
Statistical quality control (SQC) is a tool that ensures quality products or services by using control charts and sampling plans. The trends, chart patterns interpretation, and the diagnosis of assignable causes require expert knowledge [1].

Products with many components usually have many opportunities for failure or defects that occur. Motorola developed the Six Sigma program in 1980 in response to the demand for their products. The focus of Six Sigma is to reduce variability in key product quality characteristics at the level where failure or defects are highly unlikely [2]. The Six Sigma methodology targets the variation in processes identifies and eliminates the mistakes or changes to improve the quality and performance of business processes [3]. 99.99966 percent of the products have to be defect-free, which means that only 3.4 defected units per million opportunities (DPMO) [4,5,6].

Counting defects during processes is not the focus of Six Sigma, but the number of opportunities within a process that could result in error, which eliminated causes of the quality problems before they become defected products [7]. Six Sigma could be used to increase customer satisfaction as a process that focuses on continuous improvements in business activities [8].

Previous research was done by Sembiring et al. shown that quality is a criterion that is determined for obtaining the best supplier for the tire company [9]. Proposed quality control improvements after analyzing a sugar company using the Six Sigma approach for the DMAIC method, which show that the presence of defected products is 5.664,72 DPMO and sigma value 4 to 4.5 [10]. Six Sigma for quality control analysis is also done by Sembiring for a cigarette paper company with a DPMO value of 39536 and a sigma value of 3.26 [11].

The same method also used by Anggraeni et al. The research was conducted in the T-shirt production company. A lot of defects made during production, namely screen printing, stitching on the...
fabric, packaging, and cutting. The calculation of the DPMO value is 1,975 units and sigma level of 3.10. The RPN assessment shows that there are two processes that have the high RPN value, in which packaging (RPN 512) and screen printing process (RPN 596) took responsibility. Fishbone diagram and FMEA method were also used as a proposal to improve human resources ability during the production [12].

2. Research methods
The problem formulated in this study is the assessment of the Defect of the Cutter Case produced by PT. X. The types of defects studied were melted, non-jagged, and bent. The method used in solving problems is used by the Six Sigma method, namely DMAIC (Define, Measure, Analyze, Improve, Control).

Assumptions used in this study are: Data obtained are normally distributed, if a measurement error is assumed to be correct, it is caused by the limited time to re-measure, out of control data that has been revised two times will be assumed to be in control, the limits used in this study are: attributed defects observed were melted, non-jagged, and bent, the dimensions measured are the length and width in the Cutter Case, defects that occur on the product caused by the assignable cause, the number of samples used was 450 from 45 subgroups, the sampling technique used is simple random sampling, and stratified random sampling, the measuring instrument used is a 30 cm ruler.

The object of this research is the Cutter Case. The Cutter Case will be inspected for the number of defective products and defect criteria that are met for each product unit, and the length and width of the product surface. Primary data in the form of length and width measurements and defects in the product by using a measuring instrument.

Secondary data was collected from company data in the form of product Defect data per month. This company uses an inventory control system based on the principle of make to stock where the company conducts production to be stored in a warehouse (stock).

3. Result and analysis
Data processing in this study was carried out by the DMAIC method (Define, Measure, Analyze, Improve, Control); Define: stratify the number of product defects; Measure: create attribute control and variable data control Charts, analyze variable data measurement systems, calculate defects per opportunity, and calculate six sigma values; Analyze: analyze attribute data, identify problems with Cause-Effect Diagrams and Failure Mode Effect Analysis (FMEA); Improve: determine the target of improvement, and provide alternatives for development; Control: designing Standard Operational Procedures (SOP) for companies.

3.1. Define
In the define stage, stratification of the number of product defects is carried out. The working procedure in collecting Cutter Case product attribute data is based on 3 product defects (melted, bent, non-jagged), namely: Sampling is done by stratified random sampling; The number of samples taken was 450 data; Products are divided into 45 subgroups, where each subgroup consists of 10 products; Defects from the product were observed in each subgroup, in each Defect 1 line was added to the frequency column; Fill in the table for the number of defective products.

3.2. Measurement
3.2.1. Control Chart for Attribute
3.2.1.1 Np Chart. The np Chart is a chart that shows a comparison between the number of defects and all observations. This Chart can be used for quality characteristics that can be observed only with attributes. The data used is the number of nonconforming. It then obtained UCL and LCL values.
The minus LCL value is changed to 0 because there are no defects per minus unit product. Then the data, the number of nonconforming and number of inspections, is inputted into Minitab.

![NP Chart of Number of Nonconforming](image)

**Figure 1. NP’s Map**

It can be seen on Fig.1 that no data is outside the control limits (out of control) on the np Chart.

3.2.1.2 C chart. Control Chart c illustrates the number of non-conformities or defects in a sample of varying sizes. A defective object contains at least one non-conformity, but it is very likely that a sample unit has several non-conformities, depending on the nature of its reliability. The data used is the number of inspections and the number of nonconformities. It then obtains UCL and LCL values. The minus LCL value is changed to 0 because there are no defects per minus unit product. Then the data, the number of nonconforming and the number of inspections, is inputted into Minitab.

3.2.2. Control Chart for Variable

3.2.2.1 X̅ and R chart. On Chart X̅ and R using a sample of 10. Samples were taken using random numbers for each product, then products with the ten most substantial random numbers were made, and the UCL and LCL values were calculated.

![X̅ and R Chart Revised Results](image)

**Figure 2. X and R Chart Revised Results**

It can be seen on Fig.2 that there is no data outside the control limits (out of control) on the X bar-Chart Rafler revision, but there are still variants in the graph, this is caused by the assignable cause.

3.2.2.2 X̅ and S chart. The sampling procedure for Charts X̅ and S is as follows: The sampling technique is Stratified Random Sampling; This variable defect data collection was carried out by three operators; Each operator measured the Cutter Case product 2 times; This measurement is carried out alternately from operator I to operator III per product; Then record the measurement results.
Based on Figure 3, it appears that the data on Chart $\bar{X}$ and Chart $\bar{S}$ is already in the control limit (in control) after two times of revision, so there is no need to revise the data again.

3.2.2.3 Moving Average Chart for Individual and Subgroup Data. The data used in the form of data overall the results of measurements made by operator 1 on the first measurement. Some data is outside the control limits (out of control), namely 356 data due to chance causes that result in data leaving the system. Therefore revision is made by removing data out of control and obtaining a moving average Chart of individual revised data.

It can be seen in Fig.4 (a) and (b) that the second revision data results are already within the control limits (in control), so there is no need to revise them again.

3.2.3. Calculation of Defects per Opportunity. The calculation of defects per opportunity data attribute is as follows.

$$DPO = \frac{\sum np}{\sum n} \quad (1)$$

Based on the DPO calculation, the DPO value is 0.1266. This shows that in a month's production, there is 12.66% defective Cutter Case.

3.2.4. Calculation of Six Sigma Value. Calculation manually using the sigma level conversion table process. Based on the data above, DPMO (Defects Per Million Opportunities) is calculated as follows.

$$DPMO = \frac{\text{Defect} \times 1000000}{\text{Unit Expected}} \quad (2)$$
\[
= \left(51075 \times 1000000\right) / 1728000 \\
= 29557.29
\]

After the DPMO value is obtained, which is 29557.29, the sigma level with DPMO is used using the formula = NORMSINV (Probability). Probability is the probability of production defects per the whole unit of production.

\[
\text{Six sigma level} = \text{NORMSINV} (\text{Probability}) \\
= \text{NORMSINV} (1 - (\text{DPMO} / 1000000)) \\
= \text{NORMSINV} (1 - 0.02955729) \\
= 1.88
\]

Obtained a six-sigma result of 1.88. Because the calculation in Excel does not consider interpolating the value of production defects, there is a tolerance of 1.5. The final six sigma results using Excel are 1.88 + 1.5 = 3.38. This value is approaching calculations using Six Sigma Calculator.

### 3.3. Analyze

#### 3.3.1. Histogram for Attribute
The histogram in Fig. 5 is a bar chart that shows the tabulations of data arranged according to size.

![Histogram of Total Defected Products](a) ![Histogram of Defect Stratification](b)

**Figure 5.** (a) Histogram of Total Defected Products (b) Histogram of Defect Stratification

#### 3.3.2. Pareto Diagram based on Defects
The Pareto Principle is using 80/20 rule, which means that 80% of defects that occur in the Cutter Case are caused by 20% of the Cutter Case that is defective, namely bent, melting, and non-jagged also have an impact on defect. From Fig.6 it can be seen that the cumulative percentage for the type of bent is below 80%, meaning that the Defect problem needs to be resolved.

![Pareto Chart of Jenis Cacat](a)

**Figure 6.** Pareto Diagram of Type of Defect
3.3.3. Identification of Problem Using Cause Effect Diagram. Identification of problems in the Cutter Case production process begins by defining the main factors to causes of defect, which consist of humans, materials, machines, and methods, shown in Table 1.

| Category | Main Factors | Remarks |
|----------|--------------|---------|
| Human    | Matters relating to the experience and skills of workers |
| Material | Related to raw materials |
| Machine  | Related to maintenance and use of the machine |
| Method   | Related to the method or method of work of the operator |

Then the causes of the defect are explained based on the main factors in the Why-Why tables. The focus of the problem is on the type of bent errors, because 56.1% of the products have these types of errors. In Fig. 7 can be seen the fishbone diagram.

3.3.4. Failure Mode Effect Analysis (FMEA). 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 amount of the influence (severity), events (occurrence), and detection (detection).

After that we can calculate the number of RPNs for bent defects: $120 \times 125 + 60 + 96 = 401$. Because the number of RPNs smaller than 1000, it can be concluded that the defects that occur are not too disturbing, but must still be improved. A larger RPN indicates the potential danger due to errors in humans, machines, materials, and methods during the production process are more likely to occur.

3.4. Improve

3.4.1. Setting Goals for improvement. Consumers’ specifications on the Cutter Case industry in Indonesia generally do not require that the product be 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 a perfect product in the Cutter Case industry, given the many
factors that play a role in the production process besides the tendency of high levels of human error. Based on the above thinking, the improvements made are continuous.

3.4.2. **Providing Alternatives for Improvement**. Alternative corrective actions are prepared to improve the parameters that have been identified previously. Alternative measures are made using the 5W + 1H method. It shown in Fig. 8.

![Diagram Solution Tree](image)

**Figure 8. Diagram Solution Tree**

3.5. **Control**

This stage uses the Standard Operational Procedure (SOP), which is a written standard that is used to encourage and move a group to achieve specific goals. The SOP for making Cutter Case should be completed with the objectives of the Cutter Case production procedure, an explanation of the methods, related equipment, techniques used, responsible parties, documents used, outputs, links to other systems, and the necessary attachments, such as flow process charts.

4. **Conclusions**

The conclusions that can be obtained from this study are:

In the define phase, there are 50 the number of defects and factors that affect the Cutter Case defects, namely humans, materials, machines, and methods. The type of Defect attribute on the Cutter Case is bent, melted, and non-jagged; In the measure phase, the interpretation of attribute and variable data is carried out. Six sigma value is 3.39, so that it can be said that the Cutter Case production process is quite good. In the measure phase, the defect level is obtained from the Cutter Case product, and a revision of the out of control data is carried out; In the improvement phase, suggestions for improving the quality and quality of the Cutter Case production are in the form of material and machine-oriented changes, such as increasing the checking of raw materials, adjusting the methods used with SNI, and so on; In the control phase, controlling the process of making the Cutter Case, and using tools in the form of making Standard Operating Procedure (SOP); Based on the five stages above, namely Define, Measure, Analyze, Improve, and Control, it can be concluded that the overall Cutter Case product has met both the production process and the quality and quality of the Cutter Case product.
References

[1] Kuo T and Mital A 1993 Quality control expert systems: a review of pertinent literature Journal of Intelligent Manufacturing 4(4) pp 245–257

[2] Montgomery D C 2009 Introduction to Statistical Quality Control 6th Edition (John Wiley & Sons) pp 81

[3] Mortimer A L 2006 Six Sigma: effective handling of deep-rooted quality problems Assembly Automation 26(3) pp 200-204

[4] Nakhai B and Neves J S 2009 The challenges of Six Sigma in improving the service quality International Journal of Quality & Reliability Management

[5] Pande P S, Neuman R P and Cavanagh R R 2000 The Six Sigma Way: How GE, Motorola, and other top companies are honing their performance (New York: McGraw Hill)

[6] Antony J 2002 Design for Six Sigma: a breakthrough business improvement strategy for achieving competitive advantage, Work Study, Vol 51 No 1, pp 6-8

[7] Antony J 2006 Six Sigma for service processes, Business Process Management Journal, Vol 12 No 2, pp 234-48

[8] Andersson R, Eriksson H and Torstensson H 2006 Similarities and differences between TQM, Six Sigma and lean The TQM Magazine Vol 18 No 3, pp 282-96

[9] Kartini I A N and Syarief D J 2018 Quality Control Analysis with Six Sigma - DMAIC Method in Effort Reduce Number of Sugar Products at PT PG Gorontalo Sinergi: Jurnal Ilmiah Ilmu Manajemen 8(2)

[10] Sembiring N, Matondang N and Dalimunthe A R 2019 Supplier Selection in Rubber Industry using Analytic Network Process (ANP) and Technique for Order Preference Methods by Similarity to Ideal Solution IOP Conference Series: Materials Science and Engineering 508(1) p 012091

[11] Sembiring N and Steven C 2019 Pengendalian Kualitas Pabrik Kertas Rokok dengan Six Sigma Medan: National Conference of Industrial Engineering

[12] Anggraeni A and Sugiyarto A 2020 Quality control analysis of t-shirt production process to increase company productivity by using a six sigma dmaic method case study of gareng t-shirt convection Yogyakarta Ahmad Dahlan International Conference on Mathematics and Mathematics Education 1(1) pp 120-129