Analysis of product quality control using six sigma method

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Abstract. Quality control is the activity of management to measure the quality characteristics of
the product, compare it with specifications or requirements, and take appropriate action if there
is a difference between the actual appearance of the standard. Every company needs an
operational system that can indicate and overcome defective or damaged products, the company
must control quality in each of its production processes. This study aims to determine the quality
control of production and actions that should be done by the company to reduce product failure.
The research subject used is a case study at the company, this manufacturing company produces
bottled water products. The data used in the study include primary and secondary data, and data
collection methods used are interview, observation and documentation. Analysis of the data
used in this study is the Six Sigma method which includes five stages of DMAIC analysis namely
define, measure, analyze, improve and control. This study revealed that there are five types of
defects namely lid defects, cup defects, sliding machine, volume defects, and dirty water. Based
on the calculation of sigma value, the average sigma value of company is 4.39 with 2,047.96
Defect per Million Opportunities (DPMO). Fishbone diagrams are carried out to analyze the
causal factors of defective products, namely machinery, humans, methods, and materials.

1. Introduction
The stronger competition, provision of products, and quality services become competitive advantages
of a company [1]. Every exists company must be able to maintain and increase the efficiency and
effectiveness with the aim of remain their competency and competitiveness [2]. In business competition,
the company’s ability to get customer needs is very important. The company’s ability to get customer
needs itself is greatly influenced by the level of quality provided by a company to its customers such as
product quality, price and timeliness of product delivery. Quality is the most basic thing from customer
satisfaction and success in competition. In fact, quality is the thing that should be for all sizes of
companies and for the purpose of developing quality practices and showing consumers that they are able
to find higher expectations of quality [3].

The production process is an activity to process raw materials into finished products that have a high
selling value, but in the production process there are product defects or product damage is something
that cannot be avoided.

In the production process to be able to produce good products and meet established quality standards,
quality control is needed. Quality control is very useful for the production process so there is no high
disability. In addition to the disability of the value of a product, the product will experience a decrease
in selling value because the company lacks knowledge of quality control. In addition, the cause of the
production process has decreased can be caused by three categories, namely caused by humans,
machinery and the environment.
Quality control can be applied with one method, namely Six Sigma. Recent history of quality development said that the quality improvement Six Sigma has been proved effective [4]. Six Sigma represents a parameter that measures the variance of the statistical distribution, namely standard deviation [5], traditionally sigma variables are used to measure variance in a production process [6]. Six sigma terminology states that the sigma level is reflected as a company performance [7].

Six Sigma itself is a method used in business management strategies that can increase the business of the company periodically by design and observe business activities to reduce waste and resources, to increase customer satisfaction. To reduce the number of defects, you can use the DMAIC concept, otherwise known as the define, measure, improve and control cycle. Through optimal process parameters, this method can reduce company costs to save business [8].

This research was conducted at a company engaged in the manufacture of bottled water products, to determine the quality of the product and the type of defects produced. In addition, this study uses a causal diagram method to find out the causes of defects so that it can provide suggestions for improvement to improve the quality of the product.

2. Methods

2.1. Preliminary research
Preliminary research was conducted by conducting a survey to the company. Preliminary research is carried out in two ways, namely the first observation of the company's business processes and general study of the company through preliminary research, it can be seen also the business processes that are running at the company. In addition to conducting direct observation, discussions were also held with the company.

2.2. Defining the problem
After making direct observations and interviews, several problems were encountered by the company. The problems found will be appointed as an identification of problems that will be solved in this study.

2.3. Literature review
After defining the problem, a literature study will be carried out related to the problems taken as the research topic. Library studies carried out are using literature books, journals, or the internet. Literature studies carried out are expected to be a foundation for solving problems that exist in the company.

2.4. Data collection
At this stage, data collection is needed to solve the problem. Data collection is done both directly and indirectly. Direct data collection is done by interviewing the parties related to the existing problems and further direct observation of business process activities. Indirect data collection is done by retrieving data that has been stored by the company. The data collected included data and defects production of 220 ml bottled water.

2.5. Data processing
At this stage through the DMAIC process, the final result of the sigma value is obtained. DMAIC is a method of measuring sigma values consisting of define, measure, analysis, improve and control. Define is the first step in improving quality where problems are identified. Measure is a measurement activity of the previous process (basic measurement), which aims to evaluate based on existing goals. In this step the information or data is collected. Some of the tools used in this step include using control charts, data collection forms, flow diagrams, pareto diagrams, scatter diagrams, frequency plots. Analyze is the stage where identification of the root cause of the problem is carried out based on data analysis. The results of the analysis can be used to create solutions in developing and improving the observed processes. Improve is the stage where testing and implementation of solutions is done to eliminate the causes of problems that exist and improve existing processes. And control is the last step taken in
improving quality using DMAIC. This final step aims to exercise control in every activity, so that good results are obtained and can reduce time, problems, and costs that are not needed.

Table 1. Explanation of Achieving Sigma Levels

| Sigma Level of Achievement | DPMO     | Information             |
|---------------------------|---------|-------------------------|
| 1-sigma                   | 691.462 | Very Uncompetitive      |
| 2-sigma                   | 308.538 | Uncompetitive           |
| 3-sigma                   | 66.807  | Indonesian Industry Average |
| 4-sigma                   | 6.210   | USA Industry Average    |
| 5-sigma                   | 233     | Japan Industry Average  |
| 6-sigma                   | 3,4     | World Class Industry    |

2.6. Analyze and evaluation
This stage analyzes and evaluates the production process, product quality, and identifies the causes of product defects that occur.

2.7. Conclusion and recommendation
In this final stage, the author concludes the results of data processing and also analysis to answer various problem formulations that have been determined in the previous stage. In addition, a number of suggestions were expected to be useful for the company.

3. Results and discussion

3.1. Define
At the define stage, we define the types of defects and determining CTQ. In the production of bottled water company there are several types of defects that occur in the production process. The following are types of defects: (1) Lid defects. The lid is the top cover of the product, the lid is not made by the company but ordered from another company, the lid defect is in the form of a lid on a cup that has been filled with water that is incorrect or inappropriate, namely: lid leak, tilt lid, lid inside and lid outside. (2) Cup defects. The defect is a dent cup and an empty cup without lid. (3) Sliding machine. Defective production process because the product that has been through the cutting process does not want to fall into the conveyor still attached to the holder so that the product will fall on the gutter. (4) Volume defects. The standard volume of filling a 220 ml bottled water product is exactly 220 ml. Volume defects in the form of less volume and more volume, the product is said to be less volume when the product volume is less than 220 ml with a lower limit not exceeding the line in the cup, the product is said to be more volume when fully charged without a cavity. (5) Dirty water. Defects that occur in finished products in which there is dirt due to the powder from the cup and powder from the lid.
Based on data above it can be seen that the highest type of defect is lid defects (A) with a frequency of 7,755,769 units and the percentage of the whole is 82.12%. Followed by the type of cup defects (B) as much as 957,880 units with a percentage of 10.14%, then sliding machine (C) as many as 463,785 units with a percentage of 4.91%, volume defects (D) as many as 263,795 units with a percentage of 2.79%, and the dirty water (E) is 2,939 units with a percentage of 0.03%. So the number of CTQ obtained is 5 types of defects.

### 3.2. Measure

In the measurement process, a mapping of DPMO and sigma value per period was carried out, then a P control chart was mapping for all periods.

**Figure 1.** Pareto diagram of the type of defect

![Pareto diagram](image)

Based on Fig. 3 and Fig. 4 show that there is a lack of process stability. For example, in the 19th and 20th periods there was the highest DPMO value which also caused a low sigma level value. The higher the sigma level, the better product manufacturing process carried out in the table is shown by the average DPMO = 2,047.96 and sigma value = 4.39.

**Figure 2.** DPMO value pattern graph

**Figure 3.** Sigma value pattern graph
Figure 4. P control chart

On the p control chart above, it can be seen that the proportion of defects is included in the controlled category, but there is instability in the process. In the 19th and 20th periods, the proportion of defects appeared to exceed the upper limit. This is because the number of defects in the period is different from the others which tend to be at the control limit.

3.3. Analyze

In the analyze stage, DPMO analysis is carried out so that a sigma value will be obtained, then an analysis of production defects will be carried out.

3.3.1. Data analysis of DPMO and sigma value.

In this study there were five types of defects that characterize the potential CTQ namely lid defects (A), cup defects (B), sliding machine (C), volume defects (D), and dirty water (E). Based on the calculations performed, the average value of the production is 28,185,439 units with a sigma value of 4.39 and the average value of DPMO is 2,047.96, which means that the company production process of 220 ml bottled water is categorized at USA industry average level. In addition, based on the graph of the DPMO value and the sigma level it appears that there is instability. This shows that the production process has not been done high consistently.

3.3.2. Analysis of product defect causes.

In this stage the analysis carried out the product defect causes in bottled water products 220 ml. The type of product defect to be analyzed for the root cause is lid defects (A) with the highest number of defects, contributes 7,755,769 units from a total of 9,444,168 units, because this type of defect has the largest contribution of 82.12%. Causal analysis is carried out using a causal diagram which is often referred to as a fishbone diagram. The following are the results of a causal diagram of lid defects (A) in the process of producing bottled water 220 ml:
3.4. Improve
Based on the results of fishbone diagrams, proposed improvements are made of root causes of the 220 ml bottled water are machinery, humans, methods, and materials. The proposed improvements in accordance with each cause of the problem are as follows: (1) Machinery. Proposed improvements to the machine by conducting regular and scheduled inspections and maintenance. Engine components must be available so that when the engine experiences damage, it is replaced immediately without any delay in product production. (2) Humans. To increase focus and lack of careful work can be done research on the work environment. Proposed improvements for humans are by increasing workers' knowledge by conducting training (training for workers). (3) Methods. Proposed improvements for the method, namely by monitoring the workers who do not comply with existing SOPs. (4) Material. For material errors proposed improvements that can be applied is to standardize the material to be used and meet company requirements.

3.5. Control
Stage of control or take control measures for suggested improvements. As for several control measures that will be proposed, as follows: (1) Check before the production process. This check aims to prevent interference with the engine during the production process where this inspection is carried out on all engine components. (2) Proper guidance, strict supervision, and discipline. Due to the discovery of defective products, it is necessary to have supervision that aims to avoid high product defects caused by irresponsible workers. (3) Creating a work team. Aside from the products produced by the company benefiting from workers, this teamwork can add to the sense of belonging, responsibility and can strengthen openness, sharing and communication. (4) Monitor the course of production and analyze any problems that exist in the production floor by all workers involved in the problem. When it is found that a problem in the handling process of the problem can be dealt with as early as possible with the cooperation of all workers involved (work team) or interpreted as an act of supervision and prevention.

4. Conclusions
The results of product quality research conducted at the company produce several conclusions. The sigma value obtained is 4.39 which means that the company has a product quality equivalent to the USA industry average and is good enough. However, the production process has not run stably and still deviates from the upper and lower limits. The types of defects that occur are lid defects (A), cup defects

![Fishbone diagram of lid defects](image-url)
(B), sliding machine (C), volume defects (D), and dirty water (E). The causes of product defects caused by several factors such as machinery, humans, methods, and materials. Improvements that can be made are regular and scheduled machine checks and maintenance, conducting training for workers, and providing consistent supervision of workers who do not see or do their work in accordance with the SOPs.

5. Recommendations
Based on the results of the research that has been obtained, there are some suggestions for the company. The company can implement the proposal given in this study by exercising good control over the DPMO values and sigma levels regularly and continuously. The company can focus on companies with zero defects in order to compete with foreign companies by making continuous improvements, analyzing product quality properly, and conducting supervision and control in order to satisfy customers and in accordance with the targets expected.

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