Minimizing soft tube defect level using six sigma method at PT Era Variasi Intertika

B H Simamora1* and C Pramesti2

1Leader of Performance Excellence Research Group. Management Department, BINUS Business School, Undergraduate Program, Bina Nusantara University, Jakarta, Indonesia 11480
2Management Program, Management Study Program, BINUS Business School Undergraduate Program, Bina Nusantara University, Jakarta, Indonesia 11480

Email: 1bsimamora@binus.edu; 2clarissa.risa99@gmail.com

Abstract. The purpose of this research is to examine the level of sigma that has been achieved in the production of soft tube product, determine factors caused the defect of soft tube production, provide suggestions for improvements to reduce defective products, and estimate the sigma level that will be achieved by PT Era Variasi Intertika in implementing the suggestions. The research method used was mix of qualitative and quantitative methods. The data analysis method used is Six Sigma Method using DMAIC (Define – Measure – Analyze – Improve – Control) steps. From data analysis, the sigma level achieved by the company is 3.52. The main factors causing defects of soft tube production at PT Era Variasi Intertika are problem of blanket printing, unclean production area, temperature of sealing machine which is not high enough, broken molding part in printing machine, careless employee, and machine error. The estimated sigma level that will be achieved by company when applying suggestions of improvement is 4.37. The defect will be reduced by 23.41%. Furthermore, doing these suggestions will decrease the risk of defect products that consumers will receive so the customer satisfaction will also increase.

Keywords: Six Sigma, soft tube defect, DMAIC, and Sigma Level

1. Introduction

In this current era of globalization, efficiency in all departments of companies is the key to survival. Companies cannot avoid fierce competitions in services, productions, human resources and other departments to be able to earn profit and gain stakeholders’ confidence, including it is consumers. The production process is one of the most important and most costly activities in a manufacture company. In carrying out production processes and activities, each company requires various kinds of resources and factors so that the production process can run smoothly in accordance with what is planned by the company. The product quality offered by the company can describe the company's image, the existence of the company in competing with its competitors and influencing consumer loyalty. In this study researcher found one of the challenges at PT Era Variasi Intertika which is a company engaged in manufacturing industry that produces various kinds of cosmetics and packaging of cosmetic. PT Era Variasi Intertika occurs to have too much defect of production that could harm the company if that left unresolved.
Based on the data on defects in the company, as provided in Figure 1, it can be seen that the defects that occurred are above the standard defect average that has been set by the company. Where the standard defect average of soft tube products is 25% which was obtained from interviews with the Head of Soft Tube Production at PT Era Variasi Intertika.  

![Figure 1. Graphic of Soft Tube Defects September 2017 – August 2018](Source: PT Era VariasiIntertika, 2018)

The quality of a product is a very important factor in business process, because the quality of products and production process is the most important thing that can be used as a benchmark that affected customers’ satisfaction [1], [2], [3], [4]. By using the six sigma method, company can anticipate and reduce the occurrence of products defect that can disserve the company by implementing various suggestions and inputs that companies to improve the quality of production by doing the research using DMAIC steps (Define, Measure, Analyze, Improve, Control) on Six Sigma.

Based on that background, the researcher wanted to research the production process of soft tube products using the Six Sigma method. Soft tube is a cosmetic packaging made from HDPE and LDPE type plastic in the form of a tube which is processed through an extrusion process. If the defects is allowed continues it will decrease the profit of the company, the production target is not achieved in accordance with the plan, and if the defect products accepted by the consumers, there will be consumer dissatisfaction with the product.

2. Literature review

2.1 Operational management

Operational management is an activity related to the creation of goods and services through the transformation of inputs into output [3]. Operations management is the management of systems or processes that create goods and or provide services. Operations are part of business organizations that are responsible for producing goods and or services [5].
2.2 *Six sigma*

| Yield   | DPMO  | Level Sigma | Explanation                  |
|---------|-------|-------------|------------------------------|
| 31%     | 691,462 | 1 Sigma     | Very uncompetitive           |
| 69.20%  | 308,538 | 2 Sigma     | Indonesian industry average  |
| 93.32%  | 66,807  | 3 Sigma     | USA industry average         |
| 99.379% | 6,210   | 4 Sigma     | World class industry         |
| 99.977% | 233     | 5 Sigma     |                              |
| 99.9997%| 3.4     | 6 Sigma     |                              |

Source: Sirine and Kurniawati, 2017

Six Sigma, as seen in Table 1, is a performance improvement approach that try to find and eliminate the causes of defects and mistake, reduce cycle times and operating cost, increase productivity, satisfy customer expectation, and achieving higher asset utilization that focuses on important output for fulfill customer satisfaction [6]. Six Sigma has a quality target statistically so that the defects that occurs is no more than 3.4 defects from every million units of products produced that refer to the philosophy and quality improvement program [7].

\[
DPMO = \frac{\text{Sum of Defects}}{\text{Sum of Production Units} \times \text{Opportunities}} \times 1,000,000 \tag{1}
\]

\[
\text{Sigma} = \text{NORMSINV} \left( \frac{1,000,000 - DPMO}{1,000,000} \right) + 1.5 \tag{2}
\]

**DMAIC**

1. Define: the stage to define product quality problems that occur in the company. At this stage the method the researcher uses is *(Supplier, Input, Proces, Output, Customer)* dan CTQ *(Critical To Quality)*. Where SIPOC abbreviation from suppliers, inputs, processes, outputs, and customers. The SIPOC diagram takes a high level view of a some process. The SIPOC can be used to identify the process area where the problem happen originated [8].

2. Measure: the stages of measuring processes and collecting data for product or process development, then evaluate performance, products, and processes [9]. The methods that can be used are check sheet, calculation of DPMO and Level Sigma, control chart, and others.

3. Analyze: the stages of analyzing data to determine the cause of a product or process defect [9]. The methods that can be used in this stage are fishbone diagram, histogram, Pareto diagram, flowchart, and other analyzing tools.

4. Improve: stages to improve products or processes with experiments, studies, simulations addressing the problems that have been analyzed [9]. At this stage the tool used is FMEA *(Failure Mode Effect Analysis)*.

5. Control: the stages for controlling the improvement performance of the manufacture process, then ensuring the changes have been applied in accordance with the design of the standard operating process *(SOP)* [9].

**3. Methodology**

The researcher used mixed methods with using qualitative and quantitative data. The researcher used descriptive research by collecting data from PT Era Variasi Intertika. *Time horizon* that the researcher use is *cross sectional*, where a study can be carried out with data that is only once collected in a some
period, in order to answer the research question [10]. The data is processed to analyze the challenges or problems that have been formulated to find the best solution in dealing with these challenge. The analyze tool used is Six Sigma. Six Sigma is a process to reduce costs, improve quality, and increase customer satisfaction [5].

The researcher collected data by doing interview and observations at PT Era Variasi Intertika. In the interview the researcher conducted an unstructured interview, is a in the form of question and answer activities between researcher and interviewees dari PT Era Variasi Intertika. This interview was conducted to obtain primary data in the form of soft tube defects that occur in the company and secondary data is that can be analyzed and processed by the researcher obtained from the company. In observation the researcher observes directly the activities that occurs at PT Era Variasi Intertika so that researcher get important data and important information clearly about PT Era Variasi Intertika, as shown in Table 2.

| Phase | Tools | Outputs |
|-------|-------|---------|
| Define | - SIPOC | - Find out the company’s business process |
|       | - CTQ  | - Find out what raw materials and tools are used in production |
|       | - Calculation of Sigma Level | - Find out the defects that occurred in production |
|       | - Control Chart | - Find out what raw materials and tools are used in production |
| Measure | - Fishbone Diagram | - Find out the sigma level that the company has achieved |
|         | - Histogram | - Find out whether the control performed by the company are good or not |
|         | - Pareto Chart | - Find out that causes of defects that occurred in the company |
|         | - Flowchart | - Find out the distribution of soft tube defects based on the causes of defects that occurred in the company |
| Analyse | - Brainstorming | - Find out the priority of defects that must be completed first |
|         | - FMEA | - Find out where the defects and causes of soft tube defects that occur in the company |
| Improve | - | - Find out the solutions that can be applied to reduce the level of defects and priority for implementing improvement recommendation based on the risk of defects |
| Control | - | - Estimated control results on the company |

After that phase, the researcher calculate the Cost-Benefit analyze that can be achieved by the company and calculate the estimation of sigma level that can be achieved by the company in applying the suggested improvements that has been given in the improve stage of the DMAIC process.

4. Results and discussions
This research begins by knowing first the production process that occur in the company and the problems or challenges that happened in the company. Table 3 shows the test results conducted by researcher in analyzing production defect of soft tube di PT Era Variasi Intertika:
4.1 Define

Table 3. Diagram SIPOC PT. Era Variasi Intertika

| Supplier | Input                  | Process       | Output       | Customer |
|----------|------------------------|---------------|--------------|----------|
| - Supplier of raw materials (HDPE, LDPE, Master Batch) | - Plastic Pellets | Extrude body | Soft Tube |
| - Ink supplier | - Mold                | Inject heading | Assembler |
| - Supplier of plate | - Roll printing      | Perforation   |             |
| - Supplier of vanish oil | - Roll vanish        | Printing      |             |
| - Supplier of foil | - Vanish oil          | Vanish        |             |
| - Supplier of plastic bags and caton boxes | - Inks               | Hot stamp     |             |
| - Supplier of blankets | - Foils              | Press         |             |
| - Supplier of stamping plate | - Plastic Bags       | Packaging     |             |
|                      | - Carton box         | Delivery      |             |
|                      | - Printing plate     |               |             |
|                      | - Blankets           |               |             |
|                      | - Stamping plate     |               |             |

Source: PT Era Variasi Intertika, 2018.

After knowing the production process, tools and materials needed to produce soft tube, to the customers that have been described in the SIPOC diagram (Supplier-Input-Process-Output-Customer), the next step is to make CTQ by defining the defects that occur in the soft tube production process at PT Era Variasi Intertika. CTQ (Critical to Quality) is a tool that head to specify the defects that occur in the production of soft tube and their information so that researcher are easier to analyze defects problem that occurred more specifically. At CTQ it is known that defects occur as many as 12 defects opportunities, defects that occurred in the body stage are dirty, size does not match, and surface in uneven, in the defects heading section that occur is dirty, heading is uneven, and a hole in heading are bad, in part printing defects that occur are dirty, the print result do not match the design, and there are design are not printed, in the vanish section there is vanish that does not stick, and on the press there is a tilting press and the press does not sealed properly.

4.2 Measure

Based on the calculation of DPU, DPMO, and overall sigma level by using data of soft tube production and defects at PT. Era Variasi Intertika, It can be concluded that the DPU obtained is 0.25881, the DPMO value is 21.567,5 and the sigma level that has been achieved by PT Era Variasi Intertika is 3.52 with percentage of probability without defects (yield) is 74,12% and probability of soft tube defects is 25,88%.
Based on the calculation of the control chart in Figure 2, it can be seen that the total production in the last 3 years is 21,342,901 units and there have been rejects as many as 5,523,763 units. CL Value (Control Line) is always constant. While other value can change depending on the results of the calculation and depend on the amount of production and the number of rejects that occur in each month. From the calculation of the data we can find out the UCL Limit (Upper Control Line) and LCL (Lower Control Line) in production, where the UCL Limit is 0.2640352521 and the LCL limit is 0.2535853844, which mean the value of the proportion in the control limit is 0.2535853844 - 0.2640352521 having good control and the rest must be corrected because the defect has crossed the line good control.

4.3 Analyze

Figure 3. Cause and Effect Diagram of Soft Tube Production PT Era Variasi Intertika
Source: The Results of Data Processing By Researcher, 2018
From cause and effect diagram Figure 3, it can be seen that the problem occurred in the company are soft tube defect which are influenced by 4 main factors, that is the method, environment, machine and employee factors. From these main factors, it can be seen that there are different causes of defects in each of the factor.

![Figure 3. Cause and Effect Diagram of Soft Tube Defects](image)

**Figure 4. Histogram Defects of Soft Tube PT Era Variasi Intertika**  
**Source:** The Result Of Data Processing, 2018

From the histogram Figure 4, it can be seen that the frequency of defect has occurred based on each cause of soft tube defect is like the histogram in picture 4. Next we can make a histogram to determine the priority causes of defects to reduce production defect in soft tube product in PT Era Variasi Intertika.

![Figure 5. Pareto Chart Defects of Soft Tube PT Era Variasi Intertika](image)

**Figure 5. Pareto Chart Defects of Soft Tube PT Era Variasi Intertika**  
**Source:** The Results of Data Processing, 2018
Based on the Pareto chart above Figure 5, it can be seen that there are 12 causes of soft tube defects, which 6 causes are the cause of 80% soft tube defects, these causes include blanket on the printing machine has a problem which cause defects is 19.85%, careless employee that cause defects by 14.28%, machine error that cause defects is 12.66%, unclean production area which cause defects by 12.42%, temperature of sealing machine which is not high enough which cause defects by 12.10%, and broken molding part in injection machine that caused defects is 9.30%, so the number of soft tube defect from the cause of defects is 80.61% which must be prioritized and made first repairs.

4.4 Improve

Based on the analysis using FMEA, the suggestions are provided in Table 4.

| No. | Cause of Defects                                      | RPN | Suggestion                                                                 |
|-----|------------------------------------------------------|-----|----------------------------------------------------------------------------|
| 1   | Blanket on the printing machine has a problem        | 160 | Perform machine maintenance once a month and do wiping blankets on a regular basis, which is every 50 minute. |
| 2   | Unclean Production Area                              | 144 | Clean up production area and machine every day after the production process is carried out and make additional SOP |
| 3   | Temperature of Sealing Machine Which is Not HighEnough | 120 | Perform maintenance once a month, control and check the results of adhesion press every 20 tubes at interval of one hour |
| 4   | Broken molding part in injection machine            | 56  | Machine and mold maintenance is carried out every once a month.             |
| 5   | Machine Error                                       | 49  | Machine maintenance is carried out regularly (once a month) and increase the intensity of production control results. |
| 6   | Careless Employee                                    | 40  | Conducted training in a period of once a month and increase the intensity of inspection of performance and production. |

Source: The Results of Data Processing By Researcher, 2018

4.5 Control

The suggestions that have been given can make the production control in the company better by doing some prevention activities and improving the production process and control on making soft tubes. It can be seen from the estimation of cost-benefit analysis that by applying the suggestions that have been analyzed by using Six Sigma can produce cost benefit calculation as shown in Table 5:

| Explanation                                      | Calculation / Year |
|--------------------------------------------------|--------------------|
| Maintenance cost                                 | Rp 120.000.000     |
| Employee overtime cost                           | Rp 14.400.000      |
| Additional equipment and material cost            | Rp 8.568.000       |
| Employee training cost                           | Rp 36.000.000      |
| Cost of production time used in carrying out the method | Rp 293.760.000     |
| **Total Cost**                                   | **Rp 472.782.000** |

Soft tube defect are reduced
Reducing the risk of accidents to employee
Production result is cleaner
The production area is cleaner and more comfortable
The risk of defective products that customers can receive is reduced
Risk of machine downtime is reduced
The result of soft tube production according to the standard increased by 948,672 unit

| Net Benefit | Rp       |
|-------------|----------|
|             | 475,944,000 |

Source: The Results of Data Processing By Researcher, 2018

From Cost-Benefit Analysis, it can be seen that the total cost has taken out for 1 year to make suggestions is Rp 472,782,000, then the net benefit is 475,944,000. Before applying the suggestion sigma level is 3.52, after applying the suggestion the sigma level to be 4.37.

5. Conclusions

Based on the analysis using the Pareto diagram, the causes included in the 80% priority cause of defects are blanket on the printing machine has a problem, unclean production area, temperature of sealing machine which is not high enough, broken molding part in injection machine, machine error, and careless employee or not understand the technique in carrying out production soft tube. After data processing and calculation, researcher can find out the estimated increase in DPMO level and sigma level to be achieved by PT Era Variasi Intertika in applying the improvement suggestion, the DPMO value after making repair dropped by 19,507,049 from 21,567,5 to 2,060,4591, the percentage of probability without defects (yield) up by 23.41% from 74.12% to 97.53%, the percentage of probability soft tube defects fell by 23.41% from 25.88% to 2.47%, and the sigma level increased by 0.85 from 3.52 which is included in the industry average standard in Indonesia to 4.37 where the sigma level has been achieved included in the USA industry standard.

Based on the results of processing data and observation that researcher have done, there are still many improvements to reduce the defects soft tube and eliminate the causes of defects occurs, that is by applying the Six Sigma method to the company on regular basis so the company can identify the problems that occur and find the right solution in handling the problem. The company can take several actions such as: performing maintenance on the extrude body machine, machine heading totally and on the part of mold, printing machine and press machine or sealing within once a month. On the factor careless employees, the company can train the employees once a month and increase the intensity of performance checks and the results of soft tube production. In environmental factor, the company can clean the production area and machine every day after production process is done and the implementation of a new SOP to tighten regulations and increase the intensity of control carried out in producing soft tube. In the method factor the company can check the machine and the adhesive power of press every 20 soft tube at intervals of one hour at a time and apply a blanket wiping system regularly on printing machine within once of 50 minutes during the production process on the machine.

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