Production quality improvement of Yamalube Bottle with Six Sigma, FMEA, and Data Mining in PT. B

Rina Fitriana¹, Johnson Saragih¹, Dea Prameswari Larasati¹

¹ Quality Engineering Laboratory, Department of Industrial Engineering, Faculty of Industrial Technology, Universitas Trisakti
² rinaf@trisakti.ac.id, ³ johnson_saragih@yahoo.com, ⁴ deaprameswari19@gmail.com

Abstract. PT. B is one of the manufacturing company engaged in the field of plastic packaging. One of the products produced by companies that bottle Yamalube to customer PT. Yamaha. Based on daily reports of production companies, found that the percentage of disability have an average of 14% per month in which the company standard is 5% per month. It is necessary for Six Sigma to improve the quality of the bottles with the steps Define-Measure-Analyse-Improve-Control (DMAIC). In the define phase diagram created SIPOC and Quality Plan Yamalube bottle production process. In the measure phase created Sigma level. At this stage the known value of 0.16 DPU, DPMO of 250,000 and the results showed that the conversion DPMO sigma level Yamalube bottle production process is equal to 2.17. In the analyze phase using a decision tree is known that bottles attributes that influence the decision of rejection is the position of the label, the number of labels, colours and perforated. By using FMEA method is known that improvements will be prioritized on the label of disability are not two sides to the root cause of the wear rubber. Repairs carried out by making the inspection SOP rubber, checksheet and proposals in the form of anti-static vacuum tool.

Keywords: Six Sigma, DMAIC, Decision Tree, FMEA,

1. Introduction

PT. B is one of the manufacturing company in the field of plastic packaging which was founded in 1997 and has one branch in Cikarang. Due to the variety of the products produced, the company received orders from various companies in the form of products and wide range of colours. The number of plastic bottles were booked also relatively high so that the production process runs for 24 hours. In one line of blow moulding machines, namely B-42 engine that produces Yamalube bottle, found the number of defects with an average percentage of 14%, which target the defect percentage set by the company amounted to 5%. It is therefore necessary improvements using Six Sigma methods to minimize the level of defects in the product bottle Yamalube by identifying defects.

Six Sigma is an organizational approach to eliminate distortions and reduce waste in the process by using statistical science approach.[1]

Past research is needed to become a reference in the study to be performed. As previous studies related to this study are shown in Table 1.
Table 1. Related Research and Outstanding Research

| NO | TOPICS                                                                 | WRITER'S NAME                                                                 |
|----|------------------------------------------------------------------------|-------------------------------------------------------------------------------|
| 1  | Integration of Six Simadan cause effect matrix dan improvement using DOE for process improvement rolling mill Six Sigma Approach to Reduce Defect in Process of Plastic Bottle Blow Molding Machine ASB in 2000 ml | K Ganguli [2]                                                                |
| 2  | Six Sigma Approach to Reduce Defect in Process of Plastic Bottle Blow Molding Machine ASB in 2000 ml | P Adhi, N Widha, F Cheers [3]                                                 |
| 3  | Application of Six Sigma, manufacture optimum setting with DOE and manufacturing standardization QC PASS with Decision Tree FMEA application in production processes to identify risks kegagaan gloves ATM | R Fitriana, D Sugiarto, J Saragih, A Bagio [4]                                |
| 4  | Integration of FMEA and FTA in determining the root cause of disability products cause insulator DMAIC integration with FMEA to determine the PVC pipe production process improvement Integration of Six Sigma, FMEA to make improvements in product quality Making the quality control system for the production of bread using Six Sigma methods Ishikawa application to determine the cause of disability of bottled drinking water and improved use of FMEA Applying DMAIC Six Sigma to improve the maintenance process Model design of quality products by using data mining in R Bakery Company Integration of Six Sigma, FMEA and Data Mining to improving the quality of the production process of plastic bottles | N Budi, A Martanto [5] D Fitria, D Ardianto, Y Yuniati [6] D Caesaron, S John [7] D Rukmayadi, S Sugiarti [8] Safrizal, Muhajir [9] Ni Wayan, Sri Mulyani, I Wayan [10] RFitriona, J Saragih, S Sarasaty [11] L Girmanova, M Solc, J Kliment, A Divokova, V Miklos [12] M Zasadzien [13] R Fitriana, J Saragih and N Luthfiana [14] The position of current research |

2. Methods

Research had been conducted by collecting data daily reports in November 2018 and interviews with plant managers to determine the flow of the production process and defects that occur in the product.

In conducting the necessary stages of DMAIC certain methods for each phase, as for the activities to be performed and tools that will be used in each phase can be seen in Table 2.
Table 2. Details Tools DMAIC

| Phase      | Description                                      | Outputs                        | Tools and Techniques                              |
|------------|--------------------------------------------------|--------------------------------|--------------------------------------------------|
| Define     | - Defining production process                    | - Diagram SIPOC                | - Interview and discussions                      |
|            | - Defining quality plan                          | - Table Quality Plan           |                                                  |
| Measure    | - Choosing suitable control chart                | - Data In Control              | - P control chart                                |
|            | - Calculating DPMO Value                         | - Nilai DPMO                   | - DPMO Value calculation                        |
|            | - Calculating Sigma Value                        | - Nilai Sigma                  | - DPMM to Sigma value conversion                 |
| Analyze    | - Analyzing dominant defect                      | - Decision Tree                | - Data Mining                                    |
|            | - Analyzing cause and effect of defects          | - Dominant defect              | - Pareto Diagram                                 |
|            | - Creating root cause diagram                    | - Cause of defect              | - Ishikawa Diagram                               |
|            | - Analyzing decision making process              | - Root cause of defect         | - Root cause diagram                             |
|            | - Choosing prioritized improvement               | - Highest RPN value            | - FMEA                                           |
| Improve    | - Proposing improvement                          | - SOP                          | - Brainstorming                                  |
|            |                                                   | - Checksheet                   |                                                  |
|            | - Anti Static Vacuum                             | - New DPMO Value               | - DPMO Value calculation                        |
| Control    | - Calculating DPMO value after improvement       | - New Sigma Value              | - DPMO to Sigma value conversion                 |
|            | - Calculating Sigma value after improvement      |                                |                                                  |

3. Result and Discussion

In the define phase diagram SIPOC made to define the production process. SIPOC diagram is shown in Table 3.

Table 3. SIPOC Diagram

| Supplier       | Input          | Process                              | Output                           | Customer     |
|----------------|----------------|--------------------------------------|----------------------------------|--------------|
| Sales Dept     | Customer order | Order quantity given to PPIC dept    | Customer order                   | PPIC Dept    |
| PPIC Dept      | Customer order | Production Planning                  | Purchase order                   | Suppliers    |
| Incoming       | Raw material & | Transport to production floor        | Production floor                 | Production   |
| material warehouse | masterbatch    |                                      | quantity                         | warehouse    |
| Die pin        | Mixed liquid material | Shape liquid material | Parison                         | Mould        |
| Magazine       | Label          | Dipindahkan ke mould                 | Label                            | Mould        |
| Transit Area   | Yamalube bottle | Transport to shipping area           | Yamalube bottle                  | Shipping area|
| Shipping area  | Yamalube bottle | Shipping to customer                 | Yamalube bottle                  | PT. Yamaha   |

In addition, SIPOC diagram, Quality Plan is created to define the quality control is done in the company on product Yamalube bottle. Quality Plan are shown in Table 4.

Table 4. Quality Plan

| No. | Process Name      | Machine / Device / Department | Evaluation Technique | Sample               | Frequency              | Control Method                  | Reaction Plan |
|-----|-------------------|--------------------------------|----------------------|----------------------|------------------------|---------------------------------|---------------|
| 1   | Incoming Material | Magnifier Lamp                 | visual Test          | 100 gr               | per incoming material  | sampling                       | Reject / Return to supplier     |
|     |                   | Color Test Device              | Color Test           | 100 gr               | per incoming material  | sampling                       | Reject / Return to supplier     |
| 2   | Bottle Inspection | censorship                     | label Check          | unit of production   | continuous             | continuous                      | reject                      |
|     |                   | Leak Test Device               | Leak Test            | unit of production   | continuous             | continuous                      | reject                      |
|     |                   | Inspector                      | visual Inspection    | unit of production   | continuous             | continuous                      | reject                      |

Based on data from the company's daily report of November 2018, the type of defects that occurs on the product label is tilted label, the labels are not two sides, leaked bottle and a non-standard colour.
After that Critical to Quality (CTQ) is made to describe the type of disability that occurs. Critical to Quality are shown in Table 5.

| No. | Defect       | Details                                      | Occurs in the process         |
|-----|--------------|----------------------------------------------|-------------------------------|
| 1   | Tilted label| Position the label on the bottle is not straight | In Mold Labeling             |
| 2   | Missing label| Labels are not on the front and back         | In Mold Labeling             |
| 3   | Leaked bottle| There is a hole in the bottle                 | Mixing raw materials         |
| 4   | Non-standard color| The color of the bottle is too thick or thin | Melting raw materials and masterbatches |

Based on the explanation in Table 5, it is known that there are four types of disability that occurs in the bottle Yamalube products. The first disability is slanted label marked with a label that is not a straight position and occur in the process of in mould labelling. Both are not two sides of the label of disability where there is no label on the front or back of the bottle and on the process of in mould labelling. The third was a hole where there is a hole that occurs in the mixing seeds of raw materials and the fourth is not a standard colour where the colour of the bottle is too thin occurring in smelting raw materials and masterbatch (dye).

Furthermore, the map p is made to determine whether the data is within the control or not. In making the map control researcher using Minitab software. The control chart can be seen in Figure 2.

![Control chart P](image)

**Figure 1. Control chart P**

From a control chart that has been created, it can be seen that these data are under control. After making sure the data is within the control of the process capability that is calculated by calculating the DPU (defects per unit). Based on values obtained DPU calculation process capability by 0:16. After calculating process capability, then the value will be calculated DPMO. DPMO calculation results show that the possibility of defects in the amount of 1,000,000 units of production is 250,000 units. Having obtained the DPMO values Sigma value will be calculated and the calculation results obtained from Sigma value is 2.17.

The next step is the Analyze phase where it will be made a decision tree disability Yamalube bottle using Weka software 3.8. The results of the decision tree shown no figure 2.
Based on the decision tree, we can conclude that the position of the label discount most impact, followed by a number of labels, the colour of the bottle and a hole in the bottle. To facilitate the understanding of the decision tree is made if then rules. Then there are five If the Rules of the result of making a decision tree. Table if then rules can be seen in Table 6.

Furthermore, the calculation of Risk Priority Number (RPN) with FMEA method by multiplying the value of Severity (S), Occurrence (O) and Detectability (D). The calculations show that disability is not a two-sided label has the highest RPN value is 336. Table FMEA calculation can be seen in Table 7.

### Table 6. If Then Rules

| No | Fungsi |
|----|--------|
| 1  | If position "MIRING"  
If Position "TEPAT"  
LABEL "SATU"  
Then category "REJECT" |
| 2  |  
If POSISI "TEPAT"  
LABEL "DUAA"  
WARN "OK"  
BOLONG "TIDAK"  
Then KATEGORI "REJECT" |
| 3  |  
If POSISI "TEPAT"  
LABEL "DUA"  
WARN "OK"  
BOLONG "YA"  
Then KATEGORI "PASSED" |
| 4  |  
If POSISI "TEPAT"  
LABEL "DUAA"  
WARN "OK"  
BOLONG "YA"  
Then KATEGORI "REJECT" |
| 5  |  
If POSISI "TEPAT"  
LABEL "DUA"  
WARN "TIDAK"  
Then KATEGORI "REJECT" |

| Function Process | Potential Failure Mode | Potential Effect of Failure | Severity | Potential Cause of Failure of process | Occurrence | Current Control | Detection | Recommended Action | RP N |
|------------------|------------------------|-----------------------------|----------|---------------------------------------|------------|-----------------|-----------|--------------------|------|
| Resin melting    | Non-standard color     | Rejected bottle             | 5        | Extruder temperature is not standardized | 6          | Temperature check | 6         | Extruder standardized temperature | 180  |
| Bottle shaping and in mould labelling | Missing label | Rejected bottle | 8 | Vacuum rubber is worn out  
Storage temperature is too high  
Label is not stored correctly | 6 | Vacuum check | 7 | Vacuum check SOP | 336  |
|                  | Tilted label           | Rejected bottle             | 8        | Magazine check | 5 | Magazine check standard | 3 | Magazine check standard | 120  |
feels rough, it can be categorized as the rubber is worn out. One final indicator rubber stiffness. When
the rubber is worn out the rubber will become stiff and inflexible.

Therefore made recommendations for improvement is to establish Standard Operating procedure (SOP) inspection rubber vacuum mouth. The SOP is shown in Figure 3.

![Figure 3. SOP Inspection rubber vacuum](image)

Check sheet need to be made to ensure that when the rubber is in check, the gum condition and the action taken. Check sheet shown in Figure 4.

Repair using SOP and check sheet are improvements that can be made in the near term, while the proposed improvements in the long term is to replace the vacuum mouth with anti-static vacuum shown in Figure 5.

![Figure 5. Anti-Static Vacuum](image)
1. The arm will take the label by using a vacuum
2. The label will be attached to the bearing surface of the vacuum. At the same time, the voltage of 12kV 7- given for 35 to 60 milliseconds on a plate in a vacuum and the wind stopped
3. The label will be attached to the pads and arm moves towards mold
4. Sleeve label release in the mold

4. Conclusion
Based on the results of data processing that has been done, the conclusion of this research as follows:
1. After calculation of DPMO known that DPMO value amounted to 250,000 units, and the result of the conversion value to the value of Sigma obtained DPMO sigma level at 2.17
2. The highest RPN value is 336, on the label is missing label caused by a worn rubber vacuum mouth.
3. Based on decision tree who has made it known that most influential attribute bottle to bottle disability is the position followed by the number, colour and perforated.
4. The improvement is given based on the results of data analysis is making SOP, check sheet and anti static vacuum.

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