# Improvement Of Production Quality Of Silver Foil Using Green Six Sigma And FMEA Method

**Riwayati Triswanti, Ellysa Nursanti, Fourry Handoko**

**Abstract:** PT. Megahjaya Cemerlang (MGJ) is a company manufacturing silver foil that face minor problem on its silver foil quality. Every month, MGJ usually receive 1 complaint about nonconformity of quality from its customers, such as nonconformity of size, color defect, loose rolls and nonconformity of core. Such complaints arise from checking when silver foil received by customer and when it is used during production process. This study aimed to obtain an improvement in the quality of silver foil production. The sample of this study was types of process starting from the receipt of raw materials until the delivery process. The sample was taken based on the type of production process carried out during the data collection period from May 01, 2020 to May 22, 2020. The methods used in this study were DMAIC and FMEA. Based on the results of the study, it is concluded that the improvement of quality with six sigma using the DMAIC method can reduce the number of defect from 7% to 4,5% also increasing sigma value from 1,91 to 2,4 and risk analysis using FMEA obtained the highest RPN value of 320 which was due to the absence of checking the raw materials at the time of acceptance or arrival of raw materials, from implementation of Green Six Sigma can get efficiency raw material used with amount 71.910.000 IDR during 22 days production.

**Index Terms**: FMEA, Green Six Sigma, Silver Foil, Quality

## 1 INTRODUCTION

PT. Megahjaya Cemerlang is a printing company, one of their production is Silver Foil. In all company quality is always a priority so that companies want to improve the quality of their products by reducing the number of production defects. Quality is "conformance to requirement", which is in accordance with the required or standardized [1], In several studies that have been done there those that use analysis by use six sigma methods, implementation of green, reducing waste also improvement quality [2,3,4,5,6,7,8,9,10,11]. Six sigma is a method or control technique to eliminate irregularities and reduce waste in the process [12].In several other studies that have also been carried out using analysis by use FMEA method for minimize risk and improvement quality priorities[13,14,15,16]. FMEA is a structured procedure ti identify and prevent as many failure modes as possible [17]. To complement the studies that has been done, this study also uses the six sigma with DMAIC method. Besides that, it is also added to the implementation of the application for green so that efficiency can be obtained in reducing the use of raw materials. As well as a risk analysis using FMEA in order to know the priority improvements that must be done. MGJ have issue with the quality of its silver foil. Every month, MGJ received around 1 complaint about non-conformity of quality from its customers, such as nonconformity of size, color defect, loose rolls and nonconformity of core.

Complaint about silver foil arise from checking when silver foil received for the first time by the customer, which is in the end the silver foil must be returned to MGJ. The problems faced by PT MGJ must be resolved immediately considering that quality is very important and currently the number of defects in MGJ is 7%, exceeding the standard set by the company, which is 5%, also for reprocessing or producing the silver foil that has been returned. from customers requires time, cost and additional use of raw materials. So that the purpose of this study is to obtain an increase in the quality of silver foil production.


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## 2 METHODS

This study used applied research type with quantitative data [18]. The stages carried out in data analysis are as follows:

**1. Define**

Identifying problems by observing and conducting interviews directly with the company

**2. Measure**

At the measure stage, a determination is made for CTQ (Critical To Quality).

**3. Analyze**

Analyzing the foil quality problems that occur during the study as a basis for determining which CTQ has the most influence on foil defects using Pareto, and also analyzing the causes of defects using fishbone. Then an analysis was carried out using FMEA to identify and analyze the most defects as a preventive measure

**4. Improve**

Determine the improvement plan after knowing the root of the problem that occurred by providing suggestions / recommendations for improvements

**5. Control**

Determine the control period for the implementation of the improvement results so that no recurring events occur

**6. Green**

Designing an environmentally friendly manufacturing system by changing the management of raw materials, reducing energy use, production processes, efficiency in both time and labor and reducing adverse impacts on the environment

## 3 RESULT AND DISCUSSION

### 1. Define

To find out the correct identification of the problem, observations and direct interviews were made and then made a SIPOC diagram, namely: Supplier - Input - Process - Output - Customers to find out in detail which parts need improvement. Figure 1 shows a SIPOC diagram for the foil process from suppliers to customers

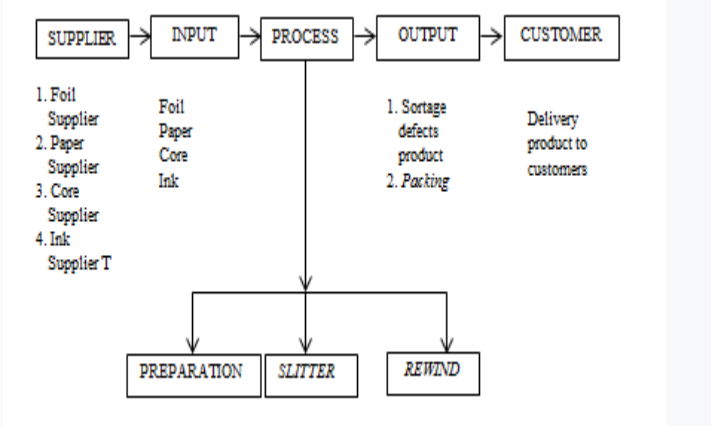


***Fig 1.*** *SIPOC Diagram*

## 2. Measure

Determine of CTQ (Critical To quality) characteristic with make list all customers needed from all current complaint also data from production performance and incoming raw materials data, Get 7 Critical To Quality, that is:

1. Loose Roll
2. Line Of Foil
3. Incorrect Size
4. Peeling Off
5. Unstable Roll
6. Wrinkle
7. Incorrect Core
8. Analyze

## 3. Analyze

Analyze using six sigma tools that is pareto diagram and fishbone diagram, pareto diagram show in Figure 2. based on pareto diagram, it shows that the highest defect is found in loose roll with percentage of 33% or 73 rolls from total foils inspected of 2425 rolls and a total of 220 rolls were defect foil product. As a result, this focuses on the loose roll defect

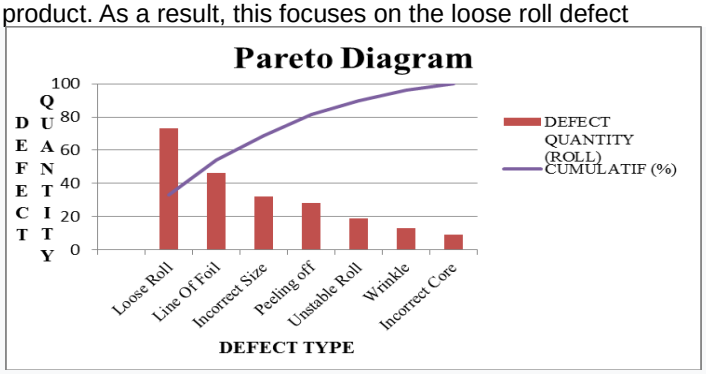


***Fig 2.*** *Pareto diagram*

After knowing the type of CTQ with the highest percentage in the Pareto diagram, namely loose roll defects, in Figure 3 analysis of all factors is carried out to determine the cause of the defect with a fishbone diagram

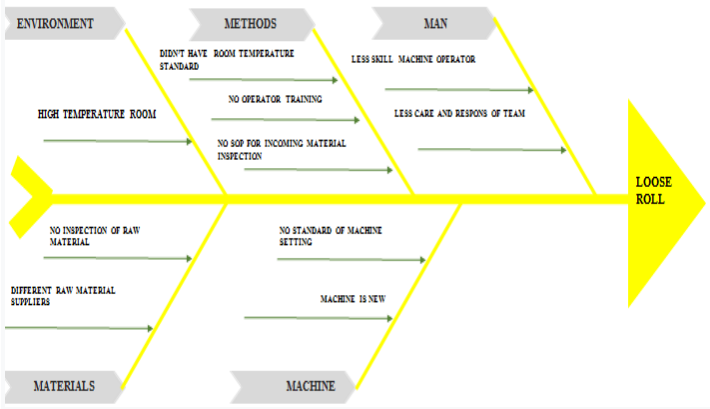


***Fig 3****. Fishbone Diagram*

The fishbone diagram shows that defect of foil in the form of loose roll occurs due to several factors, such as:

1. Human factor which is caused by inadequate skills of operator as well as less attention and response of the team to the issue occurs.
2. Machine factor which is caused by new machine where the operators have not been adapted to run and its setting has not been standardized which result in the defect.
3. Method factor. It is related to the absence of SOP of raw material acceptance, expertise or competency standard for operator to run rolling machine and also the absence of standard storage temperature in the warehouse.
4. Material factor. Raw material of foil is purchased from 2 suppliers where the specifications are not 100% the same. It causes the loose rolls. Moreover, the process of raw material acceptance is only based on delivery note from supplier without conducting rechecking.
5. Environment factor is indicated from different temperature in raw material warehouse, production area and hot temperature in finish goods storage room that cause the difference of paper moisture and result in loose rolls.

Data processing of loose rolls in DPMO calculation and level of sigma on Table 1 as follows:

***TABLE 1.***
*Calculation of DPMO and Level of Sigma of Loose Roll*

| DATE | QUANTITY OF INSPECTION PRODUCT (U) | DEFECT QUANTITY (ROLL) (D) | CTQ (OP) | DPMO | SIGMA |
|---|---|---|---|---|---|
| 2 | 75 | 4 | 7 | 7619,0 | 3,93 |
| 4 | 155 | 3 | 7 | 2765,0 | 4,27 |
| 5 | 150 | 2 | 7 | 1904,8 | 4,39 |
| 6 | 155 | 1 | 7 | 921,7 | 4,61 |
| 7 | 155 | 3 | 7 | 2765,0 | 4,27 |
| 8 | 155 | 6 | 7 | 5530,0 | 4,04 |
| 9 | 75 | 4 | 7 | 7619,0 | 3,93 |
| 11 | 150 | 7 | 7 | 6666,7 | 3,97 |

| | | | | | |
|---|---|---|---|---|---|
| 12 | 155 | 5 | 7 | 4608,3 | 4,10 |
| 13 | 150 | 4 | 7 | 3809,5 | 4,17 |
| 14 | 150 | 2 | 7 | 1904,8 | 4,39 |
| 15 | 150 | 7 | 7 | 6666,7 | 3,97 |
| 16 | 75 | 6 | 7 | 11428,6 | 3,78 |
| 18 | 150 | 5 | 7 | 4761,9 | 4,09 |
| 19 | 150 | 4 | 7 | 3809,5 | 4,17 |
| 20 | 150 | 2 | 7 | 1904,8 | 4,39 |
| 21 | 150 | 3 | 7 | 2857,1 | 4,26 |
| 22 | 75 | 5 | 7 | 9523,8 | 3,84 |
| Mean | 135 | 4 | 7 | 4837,0 | 4,14 |

FMEA (failure mode and effect analysis) is identification and analysis, as the preventive action against the large number of failed or defective product, of pareto diagram and fishbone diagram. In the Tabel 2 analysis of Loose Roll

***TABLE 2***
*Analysis of Loose Roll*

| Risk Priority Category | |
|---|---|
| Urgent Action | RPN 200+ |
| Improvement Required | RPN 100 - 199 |
| No Action (monitor only) | RPN 1 - 99 |

| Nu | Severity | Defect Causes | Occurence | Control Recommendation | Detection | RPN |
|---|---|---|---|---|---|---|
| 1 | 8 | Absence of raw material checking | 8 | Make raw material checking standard along with its checklist | 5 | 320 |
| 2 | 6 | Inadequate skill of Operator | 6 | Hold training for operator | 3 | 108 |
| 3 | 6 | The absence of standardization for storage warehouse | 6 | Make guideline on temperature and others for storage warehouse | 4 | 144 |
| 4 | 7 | Purchase of raw material from 2 suppliers | 6 | Apply same specification to both suppliers. | 4 | 168 |

Based on FMEA calculation above, it shows that the absence of checking during raw material acceptance having the highest RPN of 320 with recommendation action to conduct raw material checking during acceptance and prepare the checklist form. Second priority risk is purchase of raw material from 2 suppliers having RPN of 168 with recommendation action to make the same specification standard for 2 suppliers. Third priority risk is the absence of standardization for storage warehouse having RPN value of 144 with recommendation action to make guideline on room temperature and others for storage warehouse. Last priority risk is inadequate skill of operator having RPN of 108 with recommendation action to hold training for operator

## 4. Improve

At the stage of improving, a plan is made to reduce the defect rate of foil and improve the quality of the foil, the action plan uses 5W-1H analysis (what, where,when,why,who and how). Action plan for human factor like in the table 3

**TABLE 3**
**Action Plan For Human Factor**

| Type | 5W –1H | Description |
|---|---|---|
| Man Purpose | What | Reduce defect of foil product from human factor |
| Reason | Why | 1. In order for operators to be more skilled at work<br>2. To improve operators capabilty<br>3. To increase team awareness |
| Location | Where | Rewind room processing PT MGJ |
| When | When | When rewinding process |
| Who | Who | Operator and rewind team |
| Method | How | Conduct training to improve operator skill and also provide understanding to the team about foil products that cannot be accepted by customers |

Action plan for material factor like in the Table 4

***TABLE 4***
***Action Plan For Material Factor***

| Type | 5W – 1H | Description |
|---|---|---|
| Man Purpose | What | Reduce defect of foil product from material factor |
| Reason | Why | 1. To get good quality of raw material<br>2. In order to check the raw materials by internal quality control<br>3. To make standardize raw materials even though from different supplier |
| Location | Where | Incoming materials warehouse |
| When | When | When order raw materials and incoming materials |
| Who | Who | Warehouse team |
| Method | How | 1. Given incoming raw materials SOP<br>2. Do selection and make criteria to get good supplier<br>3. Make specification for all raw material |

Action plan for machine factor like in the Table 5

***TABLE 5***
***Action Plan For Machine Fact***

| Type | 5W – 1H | Description |
|---|---|---|
| Man Purpose | What | Reduce defect of foil product from machine factor |
| Reason | Why | 1. To have machine setting guideline<br>2. To have schedule of maintenance |

| | | machine |
|---|---|---|
| Type | 5W – 1H | Description |
| Location | Where | Production Area |
| When | When | Before and After Production process |
| Who | Who | Production and maintenance team |
| Method | How | 1. Make machine setting guideline<br>2.Make schedule of machine maintenance |

Action plan for method factor like in the Table 6

***TABLE 6***
***Action Plan For Method Factor***

| Type | 5W – 1H | Description |
|---|---|---|
| Man Purpose | What | Reduce defect of foil product from method factor |
| Reason | Why | 1.So that the production process is in the accordance with the work procedures that have been make<br>2.So that there is a standard of storing raw materials and finish products<br>3.It is neccesary to conduct training on working methods in accordance with producers to reduce the number of defects in foil products |
| Location | Where | Production area and training room |
| When | When | When production process and week end day |
| Who | Who | Production team and quality control |
| Method | How | 1.Make SOP<br>2.Make guidline for raw material storage and finish product<br>3.Do the training for production team |

Action plan for environment factor like in the Table 7

***TABLE 7***
***Action Plan For Environment Factor***

| Type | 5W – 1H | Description |
|---|---|---|
| Man Purpose | What | Reduce defect of foil product from environment factor |
| Reason | Why | 1. To provide comfortable area for all employee<br>2. Raw Materials and finished product are not affected by a hot environment |
| Location | Where | Production Area and warehouse |
| When | When | Before and After Production process |
| Type | 5W – 1H | Description |
| Who | Who | All team |
| Method | How | Make warehouse area stadardize like temperature, humidity, etc |

## 5. Control

Control is carried out by adding raw material checking procedures both at the time of receipt of raw materials and when they are to be used for the production process

## 6. Green

The green application from the results of the improvements that have been carried out has resulted in an efficient use of raw materials of Rp. 71,910,000 during the 22 days of the production process with a decrease in the percentage of the number of defects in production from 7% to 4.5%

**Ekspektation After Improvement**

From the results of the improvement, it is expected that there will be a change in the value of both the sigma value and the RPN that is better than before. An increase in the sigma value and also a decrease in the RPN value shows that the research results are as expected. The comparison of the sigma values before and after can be seen in Table 8, namely an increase in the mean value from 1.91 to 2.4 with the possibility of product damage 211.087 for 1 million production processes. Whereas the comparison of the RPN value before and after the improvement is as shown in Table 9, namely by checking the raw materials, the RPN value decreased significantly from 320 to 64

***TABLE 8***
*Comparison of sigma value*

| DATE | QUANTITY INSPECTION PRODUCT (U) | DEFECT QUANTITY (ROLL) (D) | | DPMO | | SIGMA VALUE | |
|---|---|---|---|---|---|---|---|
| | | Before | After | Before | After | Before | After |
| 4 | 155 | 4 | 3 | 1806 45 | 135 483 | 2,41 | 2,60 |
| 5 | 150 | 5 | 2 | 2333 33 | 933 33 | 2,23 | 2,82 |
| 6 | 155 | 4 | 1 | 1806 45 | 451 61 | 2,41 | 3,19 |
| 11 | 150 | 9 | 7 | 4200 00 | 326 666 | 1,70 | 1,95 |
| 12 | 155 | 8 | 5 | 3612 90 | 225 806 | 1,86 | 2,25 |
| 13 | 150 | 7 | 4 | 3266 66 | 186 666 | 1,95 | 2,39 |
| 16 | 75 | 7 | 6 | 6533 33 | 560 000 | 1,11 | 1,35 |
| 18 | 150 | 9 | 5 | 4200 00 | 233 333 | 1,70 | 2,23 |
| DATE | QUANTITY INSPECTION PRODUCT (U) | DEFECT QUANTITY (ROLL) (D) | | DPMO | | SIGMA VALUE | |
| 20 | 150 | 8 | 2 | 3733 33 | 933 33 | 1,82 | 2,82 |
| Mean | 143 | 7 | 4 | 3499 16 | 2110 87 | 1,91 | 2,40 |

***TABLE 9***
***Comparison of RPN Value***

| No | Severity | | Defect Causes |
|---|---|---|---|
| | Before | After | |
| 1 | 8 | 4 | No Checking for raw materials |
| 2 | 6 | 6 | Low skill of Operator |
| 3 | 6 | 6 | No Standardization of ware house storage |
| 4 | 7 | 7 | Purchase of raw materials from 2 different suppliers |

| Nu | Occurance | | Control Recommendation |
|---|---|---|---|
| | Before | After | |
| 1 | 8 | 4 | Create a standard for checking |

| | | | |
|---|---|---|---|
| | | | raw materials along with a checklist form |
| 2 | 6 | 6 | Hold training for operators |
| 3 | 6 | 6 | Making guidelines or temperature guidelines etc. in the storage warehouse |
| 4 | 6 | 6 | Equalizing specifications between the two suppliers |

| Detection | | RPN | |
|---|---|---|---|
| Before | After | Before | After |
| 5 | 4 | 320 | 64 |
| 3 | 3 | 108 | 108 |
| 4 | 4 | 144 | 144 |
| 4 | 4 | 168 | 168 |

## 4 CONCLUSION

From the results of the research that has been done, it is concluded that the increase in the quality of silver foil production is achieved by reducing defective products using the DMAIC and FMEA methods so that the number of product defects is reduced from 7% to 4.5%, increasing the sigma value from 1.91 to 2, 4 with the possibility of damage to 211,087 for one million times the production process, as well as reducing the highest RPN value from 320 to 64. From the implementation of Green Six Sigma that has been done, it is found that the efficiency of material use is IDR 71,910,000, -

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