

# 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 to 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.

## 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

- Riwayati Triswanti is currently pursuing masters degree program in Industrial Engineering in National Institute Of Technology (ITN) Malang, Indonesia. E-mail: [riri.azza@gmail.com](mailto:riri.azza@gmail.com)
- Ellysa Nursanti and Fourry Handoko is senior Lecturer in Industrial Engineering Department postgraduate program National Institute Of Technology (ITN)Malang, Indonesia . E-mail: [ellysa.nursanti@lecturer.itn.ac](mailto:ellysa.nursanti@lecturer.itn.ac), [fourry@lecturer.itn.ac](mailto:fourry@lecturer.itn.ac)

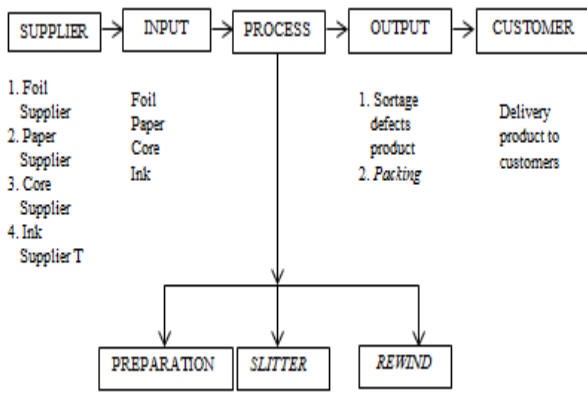


Fig 1. SIPOC Diagram

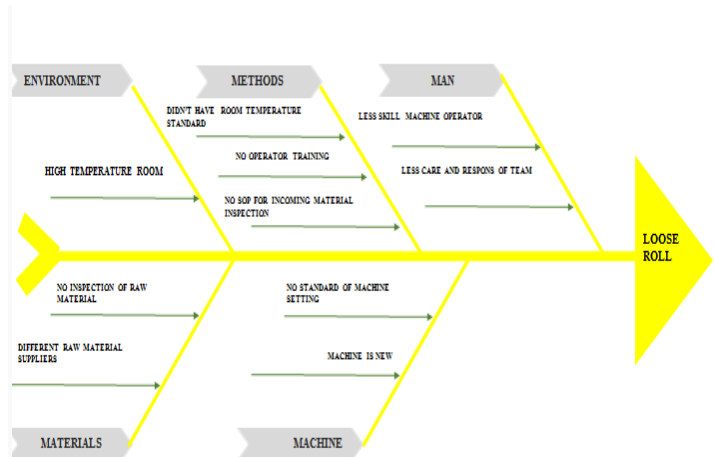


Fig 3. Fishbone Diagram

**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

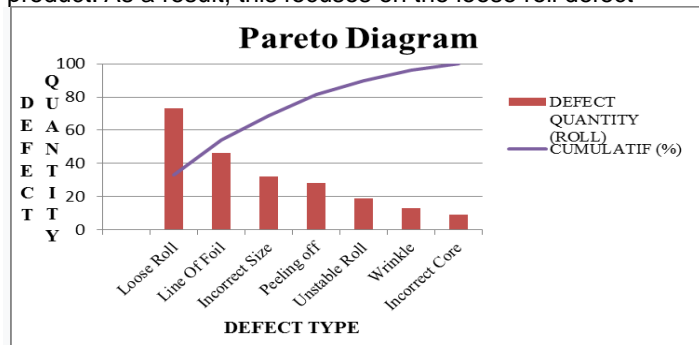


Fig 2. Pareto diagram

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

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	Sev erity	Defect Causes	Occu rence	Control Recommen dation	Dete ction	RP N
1	8	Absenc e of raw material check ing	8	Make raw material checking standard along with its checklist	5	320
2	6	Inadequ ate skill of Opera tor	6	Hold training for operator	3	108
3	6	The absenc e of standar dization for storage ware house purcha se of raw material from 2 supplier s	6	Make guideline on temperatu re and others for storage warehous e	4	144
4	7	Purcha se of raw material from 2 supplier s	6	Apply same specificati on 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 Reason	What Why	Reduce defect of foil product from human factor 1. In order for operators to be more skilled at work 2. To improve operators capability 3. To increase team awareness
Location When Who Method	Where When Who How	Rewind room processing PT MGJ When rewinding process Operator and rewind team 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 Reason	What Why	Reduce defect of foil product from material factor 1. To get good quality of raw material 2. In order to check the raw materials by internal quality control 3. To make standardize raw materials even though from different supplier
Location When Who Method	Where When Who How	Incoming materials warehouse When order raw materials and incoming materials Warehouse team 1. Given incoming raw materials SOP 2. Do selection and make criteria to get good supplier 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 Reason	What Why	Reduce defect of foil product from machine factor 1. To have machine setting guideline 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 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 1. So that the production process is in the accordance with the work procedures that have been make 2. So that there is a standard of storing raw materials and finish products 3. It is necessary to conduct training on working methods in accordance with producers to reduce the number of defects in foil products
Reason	Why	
Location	Where	Production area and training room
When	When	When production process and week end day
Who	Who	Production team and quality control 1. Make SOP
Method	How	2. Make guideline for raw material storage and finish product 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 1. To provide comfortable area for all employee
Reason	Why	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**

DA T E	QUANTI TY INS PEC TION TY PRO DUCT (U)	DEFECT QUANTI TY (ROLL) (D)		DPMO		SIGMA VALUE	
		Befo re	Af ter	Befo re	Af ter	Befo re	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
20	150	8	2	3733 33	933 33	1,82	2,82
Me an	143	7	4	3499 16	2110 87	1,91	2,40

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

Nu	Severity		Defect Causes
	Before	Af ter	
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	Occuranc e	Control Recommendation	
	Be fore	Af ter	
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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