

Identification the Potential Causes of *Stopleveline* in Electrolytic Tinning Line Using Multi Attribute Failure Mode Analysis

R. Ekawati*, N. Wahyuni, R. Annisa

Department of Industrial Engineering, University of Sultan Ageng Tirtayasa, Cilegon, Indonesia

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Abstract PT. XYZ often suffers *stopleveline* in its production process of producing tin plate type coil in Electrolytic Tinning Line (ETL) machine which is used nonstop. The purpose of this research is identifying cause of *stopleveline* and determining the most potential cause of *stopleveline* using Multi Attribute Failure Mode Analysis (MAFMA). MAFMA itself is a combination method between FMEA and AHP. The result shows the causes of *stopleveline* are damaged bearing, broken shaft, not fitted construction, damaged rubber lining in sidewall, many tin particles in roll, torn roll, groove roll and bubble roll. The most potential cause is damaged bearing by weight of 0.172.

Keywords MAFMA, AHP, Stopleveline

1. Introduction

Quality of product which meets standardize specification is an important thing that must be fulfilled by a company. If the company is not able to meet customer's satisfaction, then its customers may switch to another company. One of the obstacles that should be faced in

production process is downtime. PT XYZ is the first and largest company in Indonesia which produces tin plate. Electrolytic Tinning Line (ETL) is a primary machine in this company. Throughout 2015, PT XYZ often meets *stopleveline* in producing tin plate type coil in ETL. ETL is used nonstop so that if the machine is not operating, it will have an impact on two machines at the next station, Shearing Line (SHL) and Scroll Line (SCL). Here is the downtime historical data since July 2015 – December 2015:

Based on downtime historical data on Table 1, the cause of *stopleveline* with the greatest frequency is roll. Roll greatly affects the production process because the roll is a tool used to help the tin plate move from one process to the next process, so that if there is one roll not functioning properly, then the coil production process is interrupted. If there is no improvement to this cause of *stopleveline*, not only it is wasting time, production target is not reached and the company losses profit, but also the company should spend extra money to fix up this cause of *stopleveline*.

The purpose of this study is identifying the causes of *stopleveline* caused roll and determining the most potential cause of *stopleveline*. Assumption which is used is human factor is ignored because of machine automation and experienced operator.

Table 1. Downtime historical data

Penyebab	Downtime (minutes)					
	Jul	Aug	Sep	Oct	Nov	Nov
Coble	174	731	5	35	93	42
Electrical	401	498	244	26	195	696
Mechanical	385	681	592	977	653	1150
Operational	178	662	518	1700	1296	195
Roll	888	1446	1242	1220	936	1396

Analytic Hierarchy Process (AHP) is used to solve multi-criteria decision making issues. AHP is based on the innate human ability to use information and experience on pairwise comparison [1]. The use of AHP in this issue is often criticized because it is less able to cope with uncertainty faced by decision makers when giving an exact value in the pairwise comparison matrix. Therefore, to cover AHP then developed between AHP and fuzzy approach [2]. Fuzzy AHP method is first proposed by a researcher named Chang and a direct extension of AHP consisting of matrix elements which are represented by fuzzy numbers.

The differences between AHP method and fuzzy AHP are implementation of pairwise comparison's weight in comparison matrix. In the fuzzy AHP method, weight of pairwise comparison is represented by three variables (l, m, u) which are called Triangular Fuzzy Numbers (TFN). TFN approach in AHP method is used to minimize uncertainty in AHP scales. TFN is used by fuzzification on a scale of AHP in order to obtain a new scale called fuzzy AHP scale. Here is the following membership functions fuzzy numbers:

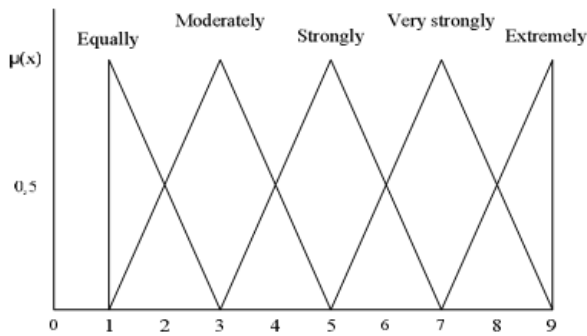


Figure 1. Membership Function Fuzzy Numbers [3]

Failure Mode and Effect Analysis (FMEA) is a method used to identify potential failure that might cause any malfunction and to make sure the effect of failure associated with any failure. The reason why we need to use FMEA, it is better to prevent failure than handle failure, increase the chances of detecting the occurrence of a failure, identify the cause of the greatest failures and eliminate them, reduce the chance of failure, and the improve quality of products and processes.

Multi Attribute Failure Mode Analysis (MAFMA) is a method developed by Marcello Braglia whose develops FMEA method. In finding the most significant cause to be controlled, FMEA considers only from three criteria's: severity, occurrence, and detectability. However there is one main factor that is no less important called expected cost. MAFMA itself is a combination method between FMEA and AHP [4].

MAFMA has already been used in previous studies include a study carried out by Hetharia, D. (2009); Badruzaman, N. (2012) Begashaw & Tafesse, (2017) and

Singh & Issac, 2018. MAFMA method is used to determine the cause of potential failures in order to improve the quality of cable products in PT Sutrakabel Intimandiri [5]. MAFMA method is used to identify the cause of failure slag on billet products [6][8]. This paper is talking about MAFMA method which is used to determine the most potential cause of *stopleveline* in Electrolytic Tinning Line in PT XYZ.

2. Methodology

Data is collected in four stages include:

1. Identification of early failure and cause of failure. Performed by conducting interviews with workers who are directly related to the production process to list the number of potential stopline and its cause.
2. Create fish bone diagram and Cause Failure Mode Effect (CFME).

It is used to see the root cause of *stopleveline* in production process by conducting interview.

3. It is used to see the root cause of *stopleveline* in production process by conducting interview.
4. Carry on pairwise comparison among alternative based on expected cost criteria.

Conducted by interviewed to know the estimation of cost by cost that should be done by the company to compensate for defective products caused *stopleveline* in the production process. After doing a pairwise comparison, then making a hierarchical structure that is used in data processing.

Here are the steps of Fuzzy AHP method in calculating the value of consistency ratio pair wise comparison matrix:

1. Calculate eigen vector using the formula:

$$F(x_{N1})(x_{N2})(x_{N3})(x_{N4})$$

Where m is the row in pairwise comparison matrix.

2. Calculate the priority weight by dividing eigen vector with total eigen vectors.
3. Multiply pairwise comparison matrix with weighted priorities.
4. Find λ_{maks} value using the formula:

$$\lambda_{maks} = \frac{\sum a}{n}$$

Where a is a total of vector sum, whereas n is the number of elements.

5. Calculate consistency index (CI) using the formula:

$$CI = \frac{h_{maks} - n}{n - 1}$$

6. Calculate consistency ratio (CR) by dividing CI with Random Index (RI) appropriate to number of paired. If $CR \leq 10\%$, then pairwise comparison is consistent. Here are the steps of Fuzzy AHP method using Chang model according to [2]:

1) Calculation the value of synthesis

Defining value of fuzzy synthetic extent for i-object such as the following equation:

$$S_i = \sum_{j=1}^m M_{g^i}^j \times [\sum_{i=1}^n \sum_{j=1}^m M_{g^i}^j]^{-1}$$

To obtain $\sum_{j=1}^m M_{g^i}^j$ then sum the value of m in

fuzzy pairwise comparison matrix such as the following equation:

$$\sum_{j=1}^m M_{g^i}^j = (\sum_{j=1}^m l_{j=1}^j \sum_{j=1}^m m_j \sum_{j=1}^m u_{j=1}^j)$$

To obtain $[\sum_{i=1}^n \sum_{j=1}^m M_{g^i}^j]$ then sum $M_{g^i}^j$

such as the following equation:

$$[\sum_{i=1}^n \sum_{j=1}^m M_{g^i}^j] = (\sum_{i=1}^n l_i \sum_{i=1}^n m_i \sum_{i=1}^n u_i)$$

To obtain the inverse of $[\sum_{i=1}^n \sum_{j=1}^m M_{g^i}^j]$

formula, it can be obtained by using TFN arithmetic operation on the following equation:

$$[\sum_{i=1}^n \sum_{j=1}^m M_{g^i}^j]^{-1} = (\frac{1}{\sum_{i=1}^n u_i}, \frac{1}{\sum_{i=1}^n m_i}, \frac{1}{\sum_{i=1}^n l_i})$$

2) Defuzzification

Defuzzification is used to convert each result which is translated fuzzy number to real number. Defuzzication is

used for each criteria such as the following equation [2]:

$$D = \frac{(u_i - l_i) + (m_i - l_i)}{3} + l_i$$

Which u: upper value in TFN

m: median value in TFN l: lower value in TFN

3) Normalization value of defuzzification

Value of defuzzification will be normalized by dividing the value of defuzzification with total value of defuzzification. Its result is weight of the problem faced such as following equation:

$$W = \frac{D}{\sum_{i=1}^n D}$$

3. Results

There are several methods of Total Quality Management (TQM) which are used to eliminate potential failure. Multi Attribute Failure Mode Analysis (MAFMA) method is one of methods of TQM which improves from Failure Mode and Effect Analysis (FMEA) method. MAFMA method integrates conventional aspects in FMEA with expected cost aspect, so that the cause of failure can be seen the effects toward cost.

In identifying the cause of stopline, this paper uses pareto diagram to know what the causes of stopline are, which dominate throughout 2015. according to pareto diagram, it shows that roll is the cause of stopline dominating in 2015. To know potentions and causes of stopline because of roll, the researchers conduct an interview and brainstorming using fishbone diagram and Cause Effect and Failure Analysis (CFMA). Then each of causes is weighted based on severity, occurrence and detectability criteria. Here is weighting result using Failure Mode and Effect Analysis (FMEA):

Table 2. Failure mode and effect analysis

Stopline Potention	Effect	S	Causes	D	Detection	O	RPN
Pressure roll malfuntion	Passed solution	8	Damaged bearing	6	Grease periodically	5	240
Broken sink roll	Not rotating roll	8	Broken shaft	4	Do crack test	4	128
		7	Not fitted construction	4	Check construction	4	112
		7	Damaged rubber lining in sidewall	4	Do leak test on rubber	4	112
Dent on tin plate	Defect	7	Many tin particles in roll	4	Control pressure roll	4	112
		7	Torn roll	4	Increase the quality of rubber roll	4	112
Creases on tin plate	Defect	7	Groove roll	4	Make arrangements of production plan	4	112
Uneven tin plate's surface	Defect	7	Bubble roll	4	Increase the quality of roll	4	112

The causes in Table 2 are taken as alternatives. There are: Damaged bearing (Cause A), Broken shaft (Cause B), Not fitted construction (Cause C), Damaged rubber lining in sidewall (Cause D), Many tin particles in roll (Cause E), Torn roll (Cause F), Groove roll (Cause G), and Bubble roll (Cause H). So that the hierarchy Structure can be seen on the picture below as Figure 2:

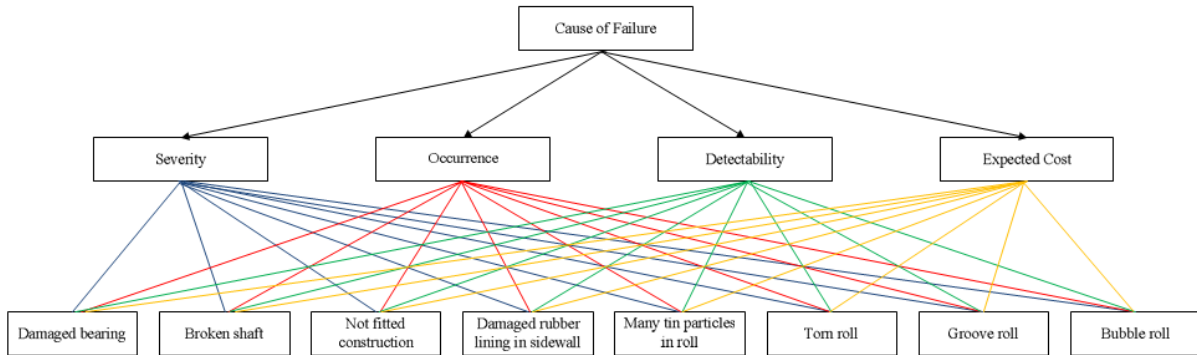


Figure 2. Hierarchy Structure of MAFMA

In weighting on pairwise comparison among all criteria uses three respondents. CR value of first respondent is 0,053; CR value of second respondent is 0,080; and CR value of third respondent is 0,080. The results from each respondent have Consistency Ratio (CR) below 10%, so that results of pairwise comparison are consistent. Then those results are done fuzzification into Triangular Fuzzy Numbers (TFN). Here is fuzzification of three respondents:

Table 3. Fuzzification among Criteria

Kriteria	S	O	D	E
S	1,1,1	11/15,16/9,10/3	3/4,11/6,10/3	7/15,11/9,7/3
O	29/60,23/18,7/3	1,1,1	13/12,13/6,11/3	7/30,4/9,1
D	29/60,17/18,2	17/36,11/12,11/6	1,1,1	7/15,11/9,7/3
E	11/15,19/9,11/3	1,7/3,13/3	11/15,19/9,11/3	1,1,1

That result of fuzzification is calculated value of synthetic extent then, defuzzification, and normalizing the value of defuzzification. From the value of defuzzification, it can be known that the weight of severity is 0,260; the weight of occurrence is 0,224; the weight of detectability is 0,193; and the weight of expected cost is 0,324.

In weighting on pairwise comparison among all alternatives based on expected cost criteria uses three respondents. CR value of the first respondent is 0,068; CR value of the second respondent is 0,064; and CR value of the third respondent is 0,076. The results from each respondent have Consistency Ratio (CR) below 10%, so that results of pairwise comparison are consistent. Then those results are done fuzzification into Triangular Fuzzy Numbers (TFN)

That result of fuzzification is calculated value of synthetic extent then, defuzzification, and normalizing the value of defuzzification. From the value of defuzzification, it can be known that the weight of damaged bearing (cause A) is 0,211; the weight of broken shaft (cause B) is 0,118; the weight of not fitted construction (cause C) is 0,154; the weight of damaged rubber lining in sidewall (cause D) is 0,070; the weight of many tin particles in roll (cause E) is 0,088; the weight of torn roll (cause F) is 0,047; the weight of groove roll (cause G) is 0,166; and the weight of bubble roll (cause H) is 0,146. FMEA is one of identifying cause of potential *stopleveline* tools in process production which is determined by RPN score based on severity, occurrence, and detectability criteria. Then FMEA is developed by adding one important criteria, expected cost, then it called MAFMA. Here is the weighting of alternatives based on severity, occurrence, and detectability which its score is taken from Table 4:

Table 4. Weighting of alternatives result based on severity, occurrence, and detectability

Cause of Stopline	Severity		Occurrence		Detectability	
	Score	Weight	Score	Weight	Score	Weight
Cause A	8	0.1379	5	0.1515	6	0.1765
Cause B	8	0.1379	4	0.1212	4	0.1176
Cause C	7	0.1207	4	0.1212	4	0.1176
Cause D	7	0.1207	4	0.1212	4	0.1176
Cause E	7	0.1207	4	0.1212	4	0.1176
Cause F	7	0.1207	4	0.1212	4	0.1176
Cause G	7	0.1207	4	0.1212	4	0.1176
Cause H	7	0.1207	4	0.1212	4	0.1176

From weighting of alternatives result based on severity, occurrence, and detectability, then it can be calculated the weight of each alternatives based on severity, occurrence, detectability, and expected cost criteria. Here is the result of weighting alternatives:

Table 5. Result of weighting alternatives

Criteria	Weighted Criteria	Cause A	Cause B	Cause C	Cause D	Cause E	Cause F	Cause G	Cause H
Severity	0.260	0.036	0.036	0.031	0.031	0.031	0.031	0.031	0.031
Occurrence	0.224	0.034	0.027	0.027	0.027	0.027	0.027	0.027	0.027
Detectability	0.193	0.034	0.023	0.023	0.023	0.023	0.023	0.023	0.023
Exp. Cost	0.3901	0.068	0.038	0.050	0.023	0.029	0.015	0.054	0.047
Total		0.172	0.124	0.131	0.104	0.110	0.097	0.135	0.128

Based on result of weighting alternatives based on severity, occurrence, detectability, and expected cost criteria, it can be concluded that damaged bearing (cause A) is the most potential cause of *stopline* in producing tin plate type coil in highest weight, 0,172. Cause A is determined as the most potential cause of stopline because it represents the highest score among four criteria than the other causes. There is no standard to determine the most potential cause because it depends on how many causes that caused the stopline. Here is the cause and effect diagram of damaged bearing:

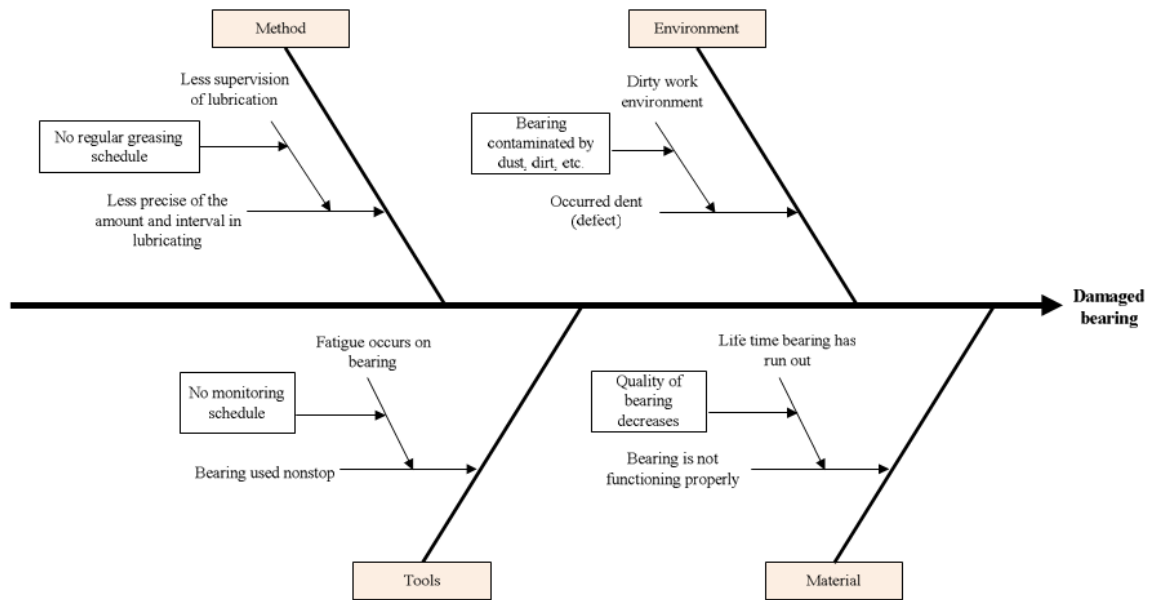


Figure 3. Fish Bone Diagram of Damaged Bearing

4. Discussion

Based on Table 5, the most potential of stopline is damage of bearing. Then we analyze what is the root cause of the damage of bearing. Using fishbone diagram, it shows that the causes are: bearing contaminated by dust, there are no periodic greasing schedule, decrease the quality of bearings, there are no periodic monitoring of bearing.

To handle contaminated dust bearing, it is necessary to check the bearings regularly every shift so that the production environment is always clean. To handle no periodic greasing schedule, it is necessary to make greasing schedule once in a week, where greasing lubrication schedule conducted according to standards that have been set. To handle the decrease of bearing's quality, it is necessary to make the periodic monitoring of quality of bearing to make sure condition of bearing is worth to use in production. To handle no periodic monitoring of bearing, it is necessary to make monitoring schedule once in a week.

5. Conclusions

The conclusion of this research is the causes of *stopline* in production process are Damaged bearing (Cause A), Broken shaft (Cause B), Not fitted construction (Cause C), Damaged rubber lining in sidewall (Cause D), Many tin particles in roll (Cause E), Torn roll (Cause F), Groove roll (Cause G), and Bubble roll (Cause H) [7].

However the most potential cause of *stopline* in producing tin plate type coil based on severity, occurrence, detection, and expected cost is damaged bearing in weight 0,172.

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