ISSN : 1978-774X

IMPLEMENTATION FAILURE MODE AND EFFECT ANALYSIS (FMEA) METHOD AND KNOWLEDGE MAP (CASE STUDY PT. GSB)

Rina Fitriana[1], Dorina Hetharia[2], Vella Denisha[3]

[123] Quality Engineering Laboratory,
Industrial Engineering Department, Industrial Technology Faculty,
Trisakti University, Jakarta, Indonesia.
rinauda@yahoo.com

ABSTRACT

PT. GSB is a manufacturing company in the field of steel structure fabrication to construction of boilers, pressure vessels, heat exchangers, and column. This research was conducted in the production process column. The production process is the process of cutting, drilling, beveling, fit-up, welding, and finishing. The failure of most potential contained in the welding process. FMEA (Failure Mode and Effect Analysis) method is used to overcome the failure to know the type of failure that occurred, the cause of the failure, the effects, and the control exercised by the company to deal with the causes of the failure. Priority repairing is in the process of welding, weld defects caused by the welding speed is too high. (RPN=360), the wrong position of welding (RPN=324), and improper welding process (RPN=315). The results of FMEA method that has the highest RPN value will be applied in the form of a knowledge map to improve product quality. The knowledge map method is used to model the aspects - certain aspects of knowledge to a map that aims to facilitate operators and workers in accessing knowledge, information retrieval, and decision-making without having to deal directly with the experts. ANOVA test performed to see the effect of welding speed with welding defects. Result from ANOVA test, reject $H_{0,}$ the welding speed which affect the welding defects where P value (0,005) ≤ α(0,05).
Keywords: *FMEA, RPN, Knowledge Map, ANOVA*

1. INTRODUCTION

PT. GSB is one of the leading companies in the field of fabrication and construction Steel Structure Boiler, Pressure Vessel, Heat Exchanger, column.

Research in PT. GSB is done in column. The process of making the column consists of cutting, drilling, beveling, fit-up, welding, and finishing. In every process there are some failures. The most potential failures are in the process of welding. This results in less good-quality products and the addition of time to make repairs. There is customer un-satisfaction because of the additional time the product delivery process be delayed. If an error occurs in the process of welding, mainly on the type of defect lack of penetration, the repair must be at the beginning of manufacture the column. To overcome these failures, we need a method FMEA (Failure Mode and Effect Analysis) and Knowledge Map.

FMEA is a systematic approach that implements a table method to assist the process of thinking used by engineers to identify potential failure modes and effect. The next step is to improve the quality of the product, then the result of the method FMEA is implemented through knowledge map. Knowledge map method is used to model certain aspects of knowledge in the form of a map that aims to make it easier to understand. In addition, This method is also used to disseminate relevant information required derived from the knowledge of an expert in the field so that it can reduce the failure process in the manufacture of products.

The purpose of the research is a potential cause of failure to obtain a mapping expert knowledge about improvements to overcome the failure of the welding process, mapping aspects of knowledge in the form of knowledge maps, improvements proposal to improve the most potential failure.

2. THEORETICAL BACKGROUND

FMEA (Failure Mode And Effect Analysis)

FMEA (Failure Mode Effect Analysis) is a design technique to systematically identify and investigate potential failure of the system (product or process) (Shirouyehzad, 2010). Calculations using the FMEA RPN ranking (Risk Priority Number) with a mathematical formula:

RPN = S x O x D

Severity (S) is severity of failures that result to the consumer or the continuity of the production process, Occurrence (O) is how often the possible causes of the failure occurred, Detection (D) shows how easily the cause of failure can be detected. The value of S, O, D ranges from 1 to 10 are used in the calculation of the FMEA.

A failure mode is what is included in the disability, the conditions set out specifications, or changes in the product that causes the disruption of the function of the product (Gaspersz, 2002).

Priority Determination Troubleshooting

Handling problems prioritization aims to determine the focus of settlement of the main issues or problems that frequently appear that the main cause of decline in product quality.

In determining priority of handling the problem, it had to determine the number of classes can be calculated by some formula:

k (sum of class) = 1 + 3,322 log n…… (1)

n = sum of data …………………….. (2)

k = $\sqrt{n}$ ………………………………..(3)

Table 1. Determination of Number of Classes

Sum of data (n)	Sum of class (k)
< 50	5 – 7
50 – 100	6 – 10
100 – 250	7 – 12
> 250	10 – 25

After determining the number of classes, in a class will have a class interval of a value up to a certain value. Here is the formula that is used to divide the class:

Class Interval = $\frac{RPN\ Max - RPN\ Min}{Jumlah\ Kelas\ (k)}$ ..... (4)

Knowledge Map

Knowledge Map is a map of knowledge collated to form a strategic and systematic system that will produce knowledge that is transparent and clear so it is easy to be transferred or disseminated
(Kim, et.al, 2003).

Knowledge map is separated into 2 component : (Kim, et.al, 2003) :

1. Diagram: model conceptual graph knowledge, which is composed of nodes and links.
   - Node: objects that show the captured knowledge of business process.
   - Link : arrows between nodes linking the relationship between knowledge.
2. Specification: depiction of a conceptual model of knowledge.

3. RESEARCH METHOD

The research methodology describe design research that includes the procedures and steps to perform data processing. Data processing in this study is done using the method. *Failure Mode and Effect Analysis (FMEA)* and *Knowledge Map*. Steps of data processing can be seen in figure 2 and figure 3.

4. RESULT AND DISCUSSION

FMEA (Failure Mode and Effect Analysis)

In the determination of making FMEA table required value Severity, Occurrence and Detection. Severity is the value of the severity of the impact on consumers and on the survival of the next process. Occurrence is how often the possible causes of the failure occurred. Detection is the rating given shows how far we can detect the possibility of errors or impacts of a fault. RPN value obtained by multiplying *severity, occurrence, and detection.*

The next stage is to determine the priority of the problem which aims to focus on problem solving to be the main cause of the problem or issue that often arises that the main cause of decline in the quality of the product column. Ways to simplify the process of choosing the cause of the failure of which would be more focused to

ISSN : 1978-774X

overcome, then performed grouping RPN value in classes that have been divided into intervals of values.

Grouping RPN value is done by the following formula (Kuswadi & Erna, 2008) :

The amount of data RPN : n = 49

Range : *RPN* max – *RPN* min = 360 – 30 = 330

Sum of class (k) : $\sqrt{n} = \sqrt{49} = 7$

Interval class (i) : *Range* / sum of class= 330/7 = 47,14

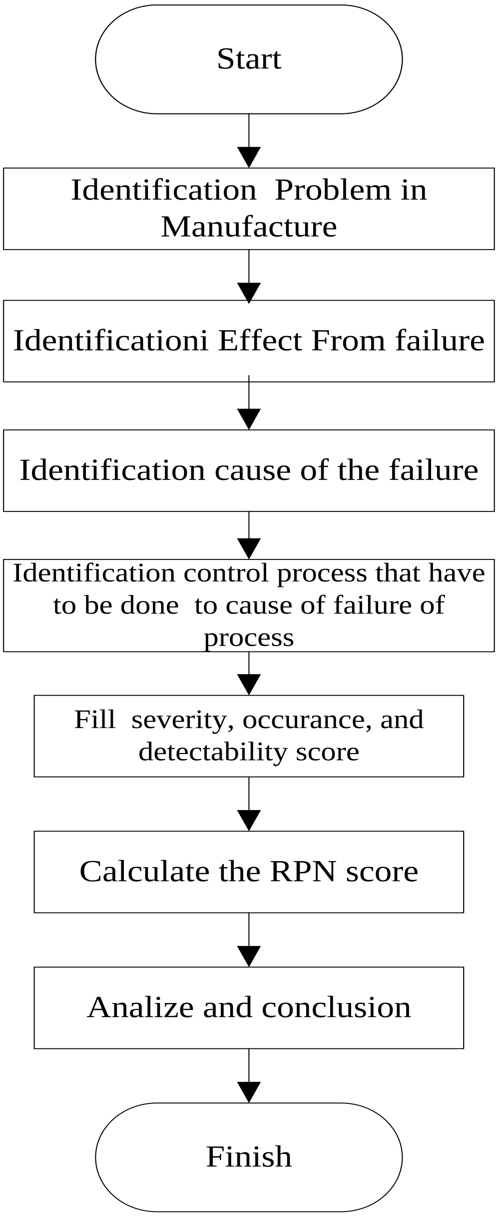

Figure 2. FMEA Method

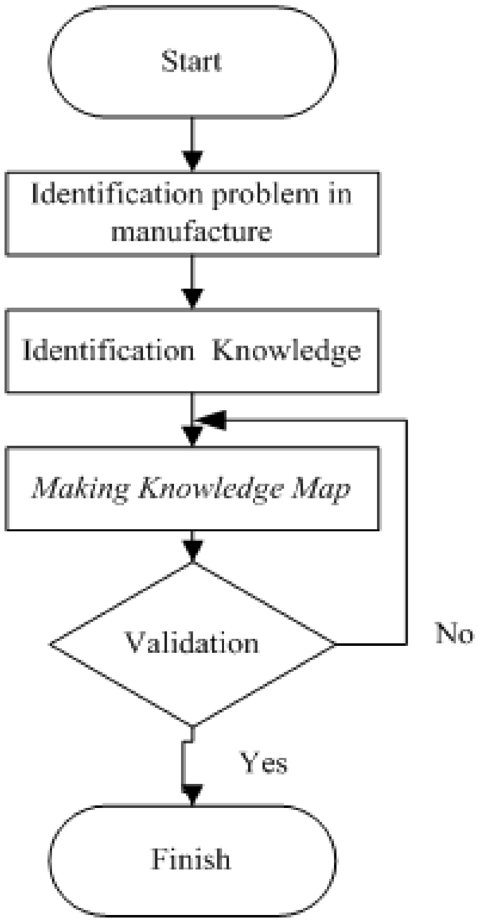

Figure 3. Knowledge Map Method

5. KNOWLEDGE MAP

The next step is to create a Knowledge Map of the failure of the process that goes into class intervals A and B. This knowledge map is aimed to increase the knowledge of operators working in order to reduce the level of product defects and product quality is increasing. In Figure 5 there is an example of creating a knowledge map that uses software inforapid knowledge map. Source of data obtained were processed from Daryanto (2012).

Table 2. FMEA Table With Priority Class Troubleshooting

Function process	Types of failures in the process	The effects of the failure of the process	S	The cause of the failure of the process	O	Control	D	Prevention Efforts	RPN	Class
Welding Column: Weld all of the material that has been assembled to main column	Defects in welding processes (slag inclusion, lack of penetration, porosity, undercut)	Allows for cracks and rust on the surface	9	The welding process is not appropriate	6	Supervision periodically by quality control division	6	Provide training to operators and to make the procedures regarding the proper welding process	324	A
				Welding speed is too high	8	Supervision periodically by quality control division	5	Provide knowledge to the operator about the use of welding speed and establishes the setting of the speed that should be	360	A

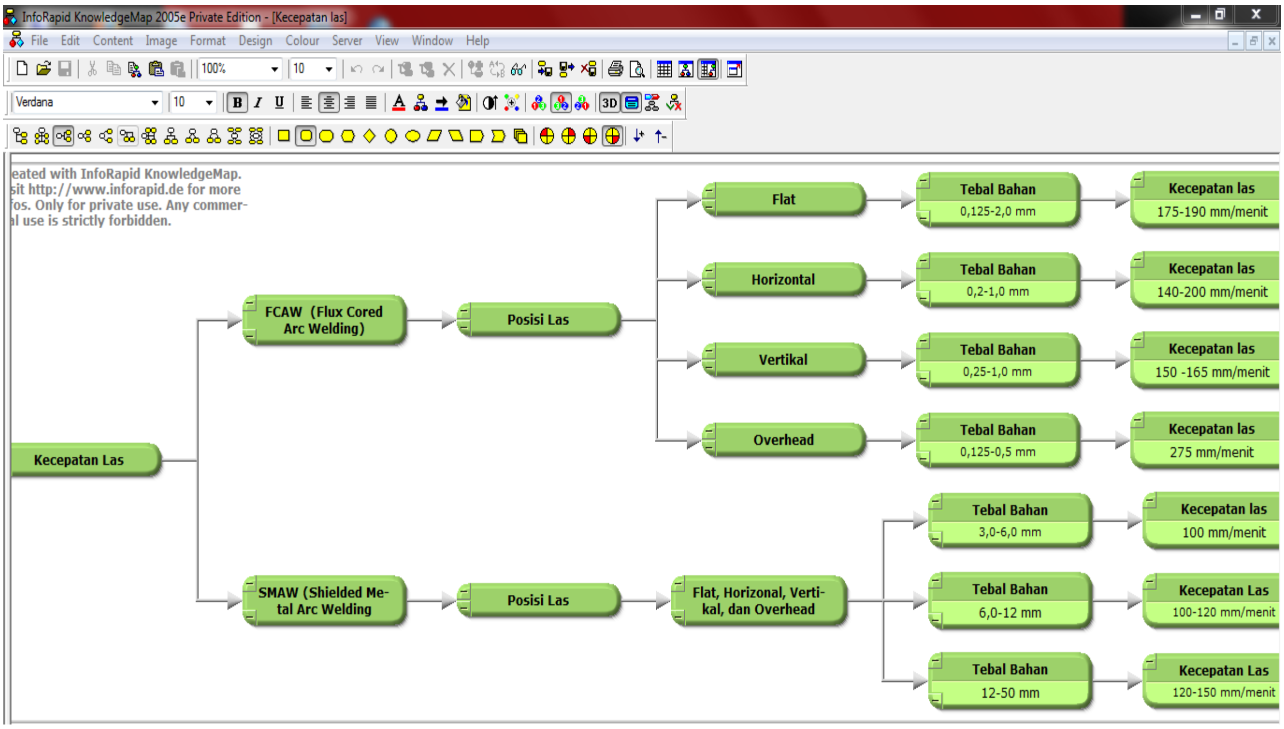

Figure 4. *Knowledge Map* for Welding Position

6. PROPOSED IMPROVEMENT BASED ON HIGHEST VALUE RPN

Handling problems will be done on the causes of failure that has the highest RPN value from FMEA table, the welding process with this type of failure is too high welding speed. To produce a good product, that there are no welding defects, the welding speed should be adjusted to the material to be welded. In this trial, we had done welding on the plate on the product column which has a thickness of 4 mm and perform welding with flat position using the SMAW process. The experiment was repeated 5 times with a welding speed of 100 mm / min, 120 mm / min, and 140 mm / min. Provisions are tested welding speed is suggested by the QC section.

Therefore, it will be tested ANOVA to obtain the welding speed otimum with welding speed testing of 100 mm / min, 120 mm / min, 140 mm / min. Table 3 is a welding speed measurement data obtained by performing the experiment:

Table 3. Data Measurement Results Las Speed (mm / min)

Las speed (mm / min)	**Defects Las (observations per 10 samples)**				
	1	**2**	**3**	**4**	**5**
100	2	3	3	2	3
120	4	3	5	3	3
140	4	5	4	4	3

ANOVA test speed Las Against Defects Las by Using Minitab

1. Ho : µ1 = µ2 = µ3
2. H_1 : At least two are not the same mean
3. α = 0,05
4. The area of criticism: Reject Ho, if the P value ≤ α = 0,05
5. Calculation Minitab 13.0 :

```
One-way ANOVA: Las versus defect Las Speed

Analysis of Variance for Defect Las
Source      DF          SS          MS
F        P
Speed    2      6,933      3,467      8,67
0,005
Error      12      4,800      0,400
Total      14     11,733

Individual 95% CIs For Mean
                                        Based
on Pooled StDev
Level        N       Mean      StDev    -----
-+---------+---------+---------+
100          5    2,6000    0,5477    (---
---*-------)
120              5       3,8000       0,8367
(------*-------)
140              5       4,2000       0,4472
(------*-------)
                                        -----
-+---------+---------+---------+
Pooled     StDev     =              0,6325
2,40       3,20      4,00       4,80
```

6. Conclusion: Reject Ho, P value (0,005) ≤ α = 0,05 concluded that the welding speed affect the weld defects.

Speed Las Against ANOVA with Disabilities Las Calculation In manual

1. Ho : µ1 = µ2 = µ3
2. H_1 : At least two are not the same mean
3. α = 0,05
4. The area of criticism: Reject Ho, if Fo > $F_{\alpha\ (v1,v2)}$
   Reject Ho, if Fo > $F_{0,05(2,12)}$ = Fo > 3,89
5. Calculation :

Table 4. Data Average Speed Results Experiment Las

Las speed (mm / min)	Defects Las (observation / 10 samples)					∑y	Ȳi
	1	2	3	4	5		
100	2	3	3	2	3	13	2,6
120	3	4	5	4	3	19	3,8
140	4	5	4	4	4	21	4,2
Total						Y..=53	Ȳ..=3,53

Table 5. Table ANOVA Free Trial Data Las Against Defect Las

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Squares	F0	Pvalue	Ftabel
Cacat Las	6,93	2	3,465	8,66	0,005	3,89
Error	4,8	12	0,4			
Total	11,73	14				

6. Conclusion: Reject Ho and conclude that the speed affect of welding defects.

Tukey test defects Las against Speed Las with Manual Calculation

1. From table ANOVA it is known :
   MSe = 0,4
   N = 15
   n = 5
   DoFe = 12
2. The order of treatment mean values from the smallest to largest:

$\bar{Y}_1$ = 2,6
$\bar{Y}_2$ = 3,8
$\bar{Y}_3$ = 4,2

3. The default value error : $S\bar{Y}_t = \sqrt{\frac{MSe}{n}}$

   $S\bar{Y}_t = \sqrt{\frac{0,4}{5}} = 0,28$

4. The value of the smallest real interval:
   $T\alpha = q_\alpha(p,f)\ S_{\bar{Y}t}$
   $T_{0,05} = q_{0,05}\ (5,12)\ S_{\bar{Y}t}$
   $T_{0,05} = (3,77)\ (0,28)$
   $T_{0,05} = 1,0556$
5. Comparison :
   $\bar{Y}_3$ vs $\bar{Y}_1$ = 4,2 – 2,6= 1,6 > 1,0556 (differ significantly)
   $\bar{Y}_3$ vs $\bar{Y}_2$ = 4,2 – 3,8 = 0,4 < 1,0556 (did not differ significantly)
   $\bar{Y}_2$ vs $\bar{Y}_1$ = 3,8 – 2,6 = 1,2 > 1,0556 (differ significantly)
6. Conclusion :
   From the calculation, the results obtained that the welding speed of 100 mm / min gives the results of different experiments weld defects compared to the welding speed of 120 mm / min and 140 mm / min.

Tukey test speed Las Against Defects Las Using Minitab

```
One-way ANOVA: Cacat Las versus Kecepatan Las

Analysis of Variance for Cacat La
Source      DF        SS        MS
F       P
Kecepata     2      6,933     3,467
8,67    0,005
Error       12     4,800     0,400
Total       14    11,733

Individual 95% CIs For Mean
                                  Based
on Pooled StDev
Level       N      Mean     StDev  -----
-+---------+---------+---------+
100         5    2,6000    0,5477   (---
---*-------)
120         5     3,8000     0,8367
(------*-------)
140         5     4,2000     0,4472
(------*-------)
                                   -----
-+---------+---------+---------+
Pooled    StDev    =            0,6325
2,40      3,20      4,00      4,80

Tukey's pairwise comparisons

    Family error rate = 0,0500
Individual error rate = 0,0206

Critical value = 3,77

Intervals for (column level mean) - (row level mean)

              100          120

     120     -2,2663
             -0,1337

     140     -2,6663     -1,4663
             -0,5337      0,6663
```

Conclusion: The results show welding speed of 120 mm / min and 140 mm / min provides measurement results do not differ significantly while welding speed of 100 mm /min measurement results differ significantly.

Analysis Tukey Test to Speed Results Las against defects Las

From the results of experiments conducted, found that the welding speed of 120 mm / min and 140 mm / min provides measurement results that are not significantly different. This was shown by the results of weld defects are formed during the welding speed of 120 mm / min and 140 mm / min is greater than during the welding speed of 100 mm/min.

It can be concluded that the welding speed of 120 mm / min and 140 mm / min yield greater weld defect in which the presence of a large welding defects, the product will often repaired and have extra time. It can be concluded to produce good welds on plate having a thickness of 4mm, you should use a welding speed of 100mm / min.

7. CONCLUSION

1. After performing calculations and grouping RPN value obtained most potential failure modes that become priorities to be prevention. Which become priorities to be addressed is the welding process that occurs weld defects caused by too high welding speed with RPN = 360, position welding wrong with RPN = 324, and improper welding process with RPN = 315. Furthermore, distortion occurs in the column assembly process caused by the use of welded

joints that are not in accordance with the material with RPN=280.

2. Knowledge development through software InfoRapid Knowledge folder folder formed by reduction of 2 types of failures that go into the process of class A and B priorities are in the process of assembly and welding processes. Assembly process caused by weld joints that is used not in accordance with the material. While in the process of welding caused by improper welding processes, welding speed is too high, and the welding position is wrong. The information that is needed to overcome the failure of each of these processes are mapped in the form of a map of knowledge that allows an operator to search for information and decision-making.
3. Proposed improvements recommended to the company of the most potential failure, which makes the test calculations ANOVA and Tukey test. Tukey test to determine the most optimum welding speed is the speed of 100 mm / min.

8. REFERENCES

(a) Daryanto. 2012. *Teknik Las*. Bandung: CV. Alfabeta

(b) Gasperz, Vincent. 2002. *Total Quality Management*. Jakarta,PT. Gramedia Pustaka Utama

(c) Kuswadi dan Erna. 2004. *Delapan Langkah dan Tujuh Alat Statistik untuk Peningkatan Mutu Berbasis Komputer*. Jakarta: Delta

(d) Shirouyehzad H, Mostafa B, Reza Di, Hamidreza P. 2010. Fuzzy FMEA Analysis for Identification and Control of Failure Preferences in ERP Implementation. *J Math Comp Sci*. 1 (4): 366-376.

(e) Suyeon Kim, Euiho Suh, Hyunseok Hwang. 2003. Building The Knowledge Map : An Industrial Case Study. *Journal of Knowledge Management*, Vol. 7, No. 2.

AUTHOR BIOGRAPHIES

Rina Fitriana is a lecturer in Department of Industrial Engineering, Faculty of Industrial Technology, Trisakti University, Jakarta. She received her Magister Management Degree from PPM Graduated Scholl of Management in 2000. She received her Doctoral Degree from Agro-industrial Engineering, IPB. Her research interests are in the area of System, Management, Quality. Her email address is <rinauda@yahoo.com>