Identification of Problem in Lorry Production Using FMEA (Failure Mode Effect and Analysis)

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Abstract— **Manufacturing company is producing lorries in large amoung thus the company is demanded to mantain and increase the consistency of the company in quality and quantity of each product unit in production process. This is done to ensure the survivability of the company in competition with the competitors. After a long operational duration, a product defect is detected due to production process, the research thus aimed to supervise and identify the source of the defect. Failure Mode and Effect Analysis (FMEA) is a method that can be used to identify the cause of defect in a production process. Thus using this method, an analysis of related factor in production process can be conducted. The result of the research showed that error was mostly happened in iron plate cutting process due to inexperienced operator, where the value of Risk Priority Number (RPN) was 21 and other process was having the value of 245. As a conclusion, the greatest defect in production process was caused by the operator.**

Keywords— **Product defect, Failure Mode and Effect Analysis (FMEA),Operator, Quality, Risk Priority Number (RPN)**

I. Introduction

In modern industry these days, industry with the same type or the same product is emerging everywhere increasingly. In fulfilling the consumer demand on the product, each industry will try its best on inovating in developing their product in accordance to consumers demands. This has been initiating tight competition between companies. Regarding this facts, every company has to have an objective to gain competitive advantage in cost or even in quality. The competitive advantage is signed by the low cost and high working efficiency, while operations were consumer oriented in terms of quality. The company to be observed is having business in lorry production, agricultural equipment and the repairment of agricultural equipment. At the moment, defects and failures were happening frequently and left undetected by the company. FMEA method is a method that can be used to identify the cause of the failures. In FMEA method, there is two mindset that being the base of analyisi, namely Failure Modes which asessed as an error or obstruction in form of process, design or physical matter mainly those who have effects on consumer potentially or actually. Analysis Effect is the part that referred to an analysis on the consequences of failures.

Previous researches regarding FMEA is numerous, some of them is the repairment and creation of innovation in project actuation and management (Bahrami, 2012). Other research mentioned that FMEA can identify the effect of failure mode application which later being useful for analysis (Trafialek, 2014). Other reasearches that has resemblance of type suppports the identification and management of vehicle components flexibly (Renu, 2016). Where in other research was using FMEA to predict failure risk in a construction process (Meraj, 2015). FMEA method is used mainly in researches that identifying risk of failures in many fields, commonly on manufacture industries, such as the analysis in electricity generator in Iran (Feili, 2013). Also some other researches in manufacture such as risk analysis in feed production (Wessiani, 2015). This kind of research was also been done to asses failure risk on offshore industries (Yang, 2014). The method has never been used to identify failure on manufacture company that produces lorries and agricultural equipments, where operator is having an important role in product manufacturing. The research attempted to obeserve deeply the problem in the industry.

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II. Research Methodology

FMEA is a systematic process to identify potential of failures that would emerge in a process with objectives to eliminate or minimize the risk of production failure. The use of FMEA was introduced for the first time on 1920. The first documentation was done since 1960 by National Aeronautics Space Agency (NASA) which was originated to improve reliabilities of military equipments (Besterfield, 1994)

The main objective of FMEA is to find and repair the main problem that happened in each stages of design and production process to prevent unqualified product to reach the consumers, which will endanger the reputation of the company.

A. *Determination of Effect of Potential Failure*

The potential failure effect is an effect that caused by a failure to a consumer. The consumer in FMEA is consisted by :

1. Downstream user / next user, which is the next process in a process flow.
2. Ultimate consumer, which is the final consumer.
3. Vehicle operation, which is a process of vehicle operation.
4. Operator safety, which is the safety of operator, those in producer factory or in assembly factory.
5. Compliance with government regulation, which is the compliance with governmental rules, such as allowed emission.
6. Machine / equipment, which is the effect on machine and other equipment, such as wear and tear or easy to break.

If the effect is in the form of breaking of govermental rules, it is suggested that identity / reference of the rules to be added to make further analysis easier.

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B. *Determination of Severity value (S)*

Severity is a rank that shows how serious is the effect of a failure mode. Severity is a number between 1 to 10, where 1 shows lowest seriousness (low risk) and 10 shows highest level of seriousness (high risk).

C. *Identification of Potential Failure Cause*

The potential failure cause is a potential cause that can result in failure. The cause of failure can be defined with correctable or controllable jargon. Namely :

1. Excessive torque pressure
2. Worn/broken equipment
3. Insufficient welding current
4. Incorrect measurement equipment

The potential cause will display only spesific error, for example, the operator installed the machine wrongly. Ambiguous jargon (such as operator error, malfunctioned machine) is advised to be avoided, for it will causing the determination of recommended action becomes difficult. It is advisable that the jargon would be replaced as follows, "operator error" to "error in work diagram reading", "malfunctioned" to "the machine fails to produce heat more than $1500^{o}C$". Potential cause can be found by using brainstorming method and fishbone diagram while considering 4M+1E factors.

D. *Occurence Value (O)*

Occurence is a measure of how often a potential cause to happen. Occurance value is a number between 1 and 10, where 1 shows low occurence or not often and 10 shows high occurence.

Occurence value can be determined by the number of failure or tha value of Ppk (Performance Index) which is a value that is obtained by statistical calculation which shows performace or capability of a process in manufacturing a product that fits the spesification. Occurence value can be lowered by preventing or controlling causes / mechanism through the design of process.

E. *Determination of Detection Value (D)*

Detection is a rank of how accurate the detection equipment that is used. Detection is a number between 1 and 10, where 1 shows detection system with high capability or can ensure a mode of failure to be detected, where 10 shows a detection system with low capability where detection system is ineffective or unable to detect at all.

Detection value can be determined using criterias as follows :

1. Error Proofed, which can be a detection equipment that is error-proofing
2. Gauging, which is an inspectoral auxiliary equipment.
3. Manual inspection, which is a manual inspection.

F. *Determining RPN (Risk Priority Number) Value*

RPN or Risk Priority Number, is a number that stated a scale of priority in quality risk which is used in guidelines in making planning. RPN is a multiplication of Severity, Occurence and Detection.

$$RPN = S \times O \times D$$

RPN is a value between 1 to 1000, where the higher RPN indicates the process is more risky in making a product with desired spesification.

III. **Results and Discussion**

The collection of data was conducted in Central Workshop of PT Perkebunan Nusantara II which is done in lorry subconstruction. The collection of data that has been done in the research was done by direct observation in each stages of lorry manufacture and interviewing every operator of each process of lorry manufacture. From the result of interview to each operators of each components manufacture of lorries, there were some defect that is frequently happened in the making of lorry components. The defects are as follows :

1. Mistake in the cuttting of front, back left and right wall and also the base part.
2. Non circular form of L shaped beams in the making of "circle".
3. L shaped beams were torn in the process of bending the internal and external chassis.
4. L shaped beams were folded in the process of bending the internal and external chassis.

A. *FMEA of Failure in Cutting*

From the existing failure, it can be observed that emerging effect by the error was the high disposing rate of good quality of iron plate.

B. *Determination of Failure Effect Value (Severity, S)*

From the interviews with the company and lorry manufacture operators, thus the Failure Effect Value (S) can be determined from the type of failure. The reason of value determination is as follows :

Iron plate that was wrongly cut will cause an effect of high dispose number of iron plate which actually has good quality, this will be assigned the value of 7, this is caused by :

- A bit disturbance of production line

- Mostly become scrap, where the rest of it can be sorted

- Consumer become dissatisfied

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C. *Identification of Potential Failure Cause*

By observing the cause and effect diagram, it can be inferred that the main cause of failure for the effect "High dispose of iron plate with good quality" was caused by :

a. Sub optimal cutting process

b. Incorrect Blander machine setting

D. *Determination of Failure Probability (Occurrence, O)*

From the interviews result with the company, failure probability value thus can be determined from failure of error in cutting which can be assigned failure probability value as follows :

1. Operator was inobservant in the cutting process thus assigned the value of 6 because the occurence can be found in 6 to 10 occurence. Thus based on the table of occurence value, it can be categorized as mediocre.

2. The incorrect setting of blander machine was assigned the value of 5 because the occurence can be found in 5 to 10 occurence. Thus based on occurence value, it can be categorized as mediocre.

E. *Identification of Failure Control Method*

By observing the existing cause of failure thus a control can be done to the cause of failure which can be done by workers or even company to minimize the risk of failure, the control method is as seen on following table.

Process Function	Type of Process Failure	Emerged Effect	The cause of failure on process	Control to be done
Lorry	Mistake in cutting	High amount of disposed good quality iron plate	• Inobservant in cutting process • Mistake in blander machine operation	• Giving trainings to operators • Giving Standard Operational Procedures of blander machine operation to operators

F. *Determination of Failure Detection Value (Detection, D)*

From the interviews with the company, the value of Failure Detection (D) of failure in cutting process can be determined. The value is a seen on the table below.

Process Function	Type of Process Failure	Emerged Effect	The cause of failure on process	Control to be done	D
Lorry	Mistake in cutting	High amount of disposed good quality iron plate	Inobservant in cutting process	Giving trainings to operators	5
			Mistake in blander machine operation	Giving Standard Operational Procedures of blander machine operation to operators	3

G. *Determining The Value of RPN*

From the interviews with the company, the value of Severity (S), Occurence (O) and Detection (D) of every type of failure that occured can be determined. For example, the calculation of RPN is as follows.

Suppose for the effect that is emerged from the high amount of good quality iron plate disposed, which is caused by inobservant operator in cutting process with operator controlled by giving trainings in cutting process.

Failure effect (Severity, S) was given the value of 7
Failure probablity (Occurence, O) was given the value of 6

Failure detection (Detection, D) was given the value of 5
Thus $RPN = S \times O \times D = 7 \times 6 \times 5 = 210$

FMEA table on the process with RPN values is entirely can be seen on following table.

Process Func.	Type of Process Failure	Emerged Effect	S	The cause of failure	O	Control to be done	D	RPN
Lorry	Mistake in cutting	High amount of disposed good quality iron plate	7	Inobservant in cutting process	6	Giving trainings to operators	5	210
				Mistake in blander machine operation	5	Giving Standard Operational Procedures of blander machine operation to operators	3	105

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H. *Failure Mode and Effect Analysis (FMEA) of mistake in circle making*

Process Funct.	Type of Process Failure	Emerged Effect	S	The cause of failure on process	O	Control to be done	D	RPN
Lorry	The L shaped beams were torn	High amount of disposed good quality L shaped beams	7	Inexperienced operator	6	Giving trainings to operators	5	210
				Inequal speed of operator and machine	5	Adjusting the speed between operators and machine	4	140
				Operators become bored	6	Assigining different tasks	5	210

I. *Failure Mode and Effect Analysis (FMEA) of folded L shaped beams*

Process Funct.	Type of Process Failure	Emerged Effect	S	The cause of failure on process	O	Control to be done	D	RPN
Lorry	L shaped beams folded	High amount of disposed good quality L shaped beams	7	Inexperienced operator	6	Giving trainings to operators	5	245
				Inequal speed of operator and machine	5	Adjusting the speed between operators and machine	4	140
				Operators become bored	6	Assigining different tasks	5	210

IV. **Conclusions**

1. The dominant failure in lorry production process is the mistake in cutting process when producing the front, back, left and right wall and base, the uncircular form of L shaped beams in circle making. Torn L shaped beams in the process of bending internal and external chassis, and folded L shaped beams in the process of bending the internal and external chassis.

2. In the process of iron plate cutting, failure emergers from operator where the operators being inexperienced with RPN value of 210.

3. In the process of circle making, failure emerges from untrained operator in circle making with RPN of 210.

4. In the process of bending of the L shaped beams which the beams are being torn, failure emerges from inexperienced operator and boredom of the operators with RPN value of 210

5. In the process of bending of the L shaped beams which the beams are being folded, failure emerges from unskilled operator in doing the process with RPN value of 245.

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