Risk analysis of warehouse operation in a power plant through a Modified FMEA

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Abstract. Currently, electricity becomes basic needs for human's life sustainability. Most of activities require electricity. Some power plant are demanded to be able to fulfil above necessity by distributing electricity as it required within time. Therefore, to accommodate good performance, it needs assessment on risk analysis, specifically at the warehousing division. A risk analysis is needed for assuring a good performance warehouse. A Modified FMEA method is used to analyse the risk. This method id done by identifying sources and root causes of a problem based on the value of risk priority number (RPN). The research is conducted in an Indonesian power plant, located in West Java. There are 10 types of failure modes. The result shows that the failure mode priority is inventory discrepancies. There are no difference ranking on the most impacted failure to be prioritized using FMEA and modified FMEA method.

1 Introduction

Electricity is one of human basic needs to support every human activity. If there are no electricity supply then all activities undertaken by humans will be stopped or obstructed. Therefore, every power plant produces electricity with continuous production, as well as minimizing the risk of occurrence of bottleneck or other production constrain. The process can be run with a good system in order to increase productivity.

A good system is done to minimize the risk of an industry [1]. There are some industries that fail to run their business processes because triggered by bad risk management. Most industries maximize the potential of assets and resources to make a profit without identifying potential risks that may occur in each of the assets or resources managed [2].

Risk is a combination of the probability and severity of an event. The amount of risk is determined by several factors, such as exposure, location, usage, quantity and the vulnerability of the elements involved [3]. Risks related to business activities should be identified, measured, assessed, mitigated, and controlled by the company. Management aims to minimize the possibility of potential losses that may be experienced by the company [4].

One unit in a company that has a big enough risk is a warehouse. Warehouse has a big influence on the company because without the warehouse then the production will be difficult to control. There are several risks in an Indonesian power plant that may cause a failure of the warehousing process, such as errors in the item code to be picked up, the amount of the stock does not match the existing records and the goods become damaged/ expired. Therefore, risk management is required to eliminate or reduce the risks by adding the necessary precautions.

The Failure Mode and Effect Analysis (FMEA) is one of the most commonly used methods to assess risk. FMEA is a structured procedure for identifying and preventing as many failure modes as possible. FMEA is used to identify the sources and root causes of a problem. Determining the cause of potential failure on FMEA is based on the highest value of risk priority number (RPN) which is the result of multiplication between severity, occurrence, and detectability. However, conventional FMEA usage often results in the same RPN, but presents different risk representations. Calculations of conventional FMEA methods weigh the severity (S), occurrence (O), and detectability (D) equally or in proportion, but in real cases these criteria have different weights [5]. To overcome that problem, weighted criteria can be done using analytic hierarchy process (AHP) method.

There are three most significant risk factors, i.e. dust, noise and gas in the occupational disease of mining industry in the south west of Hubei Province by using FMEA and AHP [6]. A multi-criteria decision making (MCDM) method is introduced in fuzzy FMEA based on fuzzy set theory in FMEA [7]. AHP-PROMETHEE method is used to prioritize failure modes in FMEA. This integration can enhance the precision of FMEA results in the field of risk assessment [8].

An improved AHP model is used to asess the risk in occupational health and safety management [9]. The most influential failure modes is determined to optimize the designing process in offshore engineering using probability network evaluation technique (PNET) and FMEA [10].

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2 Basic Theory

2.1 Failure Mode and Effect Analysis (FMEA)

FMEA is a structured procedure for identifying and preventing as many failure modes as possible. FMEA is used to identify the sources and root causes of a quality problem. There are two types of FMEA, i.e. [11]:

a. FMEA Design
   The FMEA design is used after system/ product design already determined. The FMEA design is used to analyze the product design before the manufacturing process.
b. FMEA Process
   FMEA process is used to test the error or failure mode of each stage of manufacturing and assembly process of a product.

FMEA considers three main criteria, i.e.:

- Severity is a rating of the seriousness of the consequences of failure.
- Occurrence is possible causes of failure.
- Detectability is the quantitative of the controls or procedures that exist to regulate the function or that make the failure detectable.

Risk analysis of failure modes is done using RPN (Risk Priority Number) that can be calculated based on formulation (1), where S is the severity, O is for occurrence and D is for detection value. Any failure mode with high value of the RPN is prioritized to be corrected [12].

$$RPN = SxOxD \quad (1)$$

2.2 Analytical Hierarchy Process (AHP)

AHP allows decision makers to use simple hierarchical forms to solve complex problems and to evaluate qualitative and quantitative data in systematic methodologies with attention to multi-criteria [13]. There are seven pillars in the AHP [14], i.e. ratio scale, pairwise ratio, conditions for sensitivity of Eigen vector, homogeneity and clustering, synthesis, retention and reversal sequence and group considerations.

3 Research Method

This research was conducted in an Indonesian power plant, located in West Java using five main stages. The first stage is the observation process to identify the problems found in the company especially in the warehouse. The second stage is identification of potential failures, potential causes and potential effects caused if the failure occurs in the warehouse operations process. The next stage is conducting a survey to determine the risk priority number in each failure mode and weighting FMEA criteria. FMEA modification is then performed on the FMEA criteria weighting stage, i.e. severity, occurrence and detectability using the AHP method. The value of RPN in modified FMEA can be calculated using formulation (2) [15]:

$$RPN = (WSxS) + (WOxO) + (WDxD) \quad (2)$$

Where WS, WO and WD are the relative weight of the severity, occurrence, and detectability criteria of the calculation using the AHP method. Analysis is done by comparing the RPN value of FMEA and modified FMEA. Then a failure analysis is performed to reduce the risk of failure mode that has the highest RPN value.

4 Discussion

There are ten types of failure modes identified from the warehouse operational process in Indonesian Power Plant as seen in Appendix 1. F4 and F6 are failure modes with high severity value, which can give very high effect. Both modes of failure are very influential, if F4 occurs for critical components in a frequent time, so the failure will disrupt the system. For expired materials (F6) also have a very high value of Severity, this is because some materials require special care during storage period. If the item is expired or damaged, then it cannot be used for production. On the criteria of occurrence, there are three failure modes that cannot be avoided, i.e. F1, F9 and F10. The processes that performed on the receiving process are the inspection towards delivery permit letter, amount of loads, the appropriateness of order specification. Occasionally, the numbers of incoming loads with the ordered ones are different. Failure mode F1 is considered as repetition and human errors. Later, for failure mode F9, duration of delivery process, could disturb 25% of system work, especially when the materials are considered as critical materials that urgently used in a short time. If they are late, the selling value will be reduced per day. The probability of failure is quite high, which is repeated failures. Failure mode F10 (the failure on material code that will be taken/accepted) is caused by the human error. This occurrence usually happens when there is a failure on material code or quantity. This failure mode is considered as disturbing and effects 50% of work system with the high probability of repetition.

There are two failure modes with high detectable value, among others, F8 and F10. The failure mode F8 and F10 are considered as low for detection, since on F8 or the identification of dead stock can be resumed on stock opname activity that always conducted annually, hence the possibility of detection is extremely low. On the failure mode F10, which is, the failure on material code that will be taken/ received, the detection process will be low since on the material pickup and acceptance process, sometimes the officer in charge is absent and replaced by others. It will emerge the material placement impropriate with the material code.

The calculation of RPN value by using FMEA is conducted by employing the value of severity, occurrence and detectability. F10 is determined as failure mode with the highest RPN value of 168, as described by Figure 1.

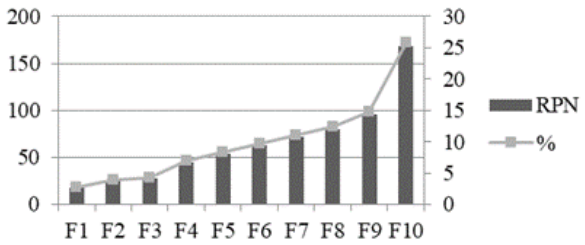

Fig 1. RPN values

This failure mode is triggered by human errors in performing material code or quantity inputting. It disturbs 50% system work with probability of repeated failures, hence the detection possibility is considered as low, probability checking will detect designated failure mode.

On the FMEA method, the weight of criteria is assumed as similar, but in real, similar RPN value will establish different effect. For instance: the value of severity, occurrence, and detectability are 6, 3 and 1 consecutively, while other failure modes are 9, 2 and 1. Both values have the same RPN value yet provide different effect. Hence, FMEA is modified with AHP to gain weight of severity, occurrence and detectability criteria. The weight of severity criteria is higher than two other criteria as illustrated by Figure 2.

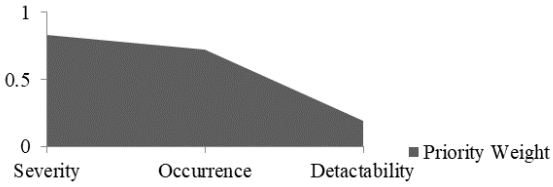

Fig 2. FMEA criteria priorities

The value of RPN in modified FMEA is obtained by using formulation (2). From identified 10 failure modes at the warehouse operation in Indonesian Power Plant, there is 80% difference between FMEA and modified FMEA as seen in Table 1. First and second ranking for both methods demonstrate similar result, hence the failure mode that contains the highest RPN value is inventory discrepancy (F10). F9 is placed on the second ranking, which is described as the delivery lead time.

Table 1. Comparison of FMEA and Modified FMEA result

No.	Code of Failure Modes	Risk Priority		No.	Code of Failure Modes	Risk Priority	
		FMEA	Modified FMEA			FMEA	Modified FMEA
1	F1	8	3	6	F6	3	8
2	F2	10	9	7	F7	7	6
3	F3	9	10	8	F8	6	4
4	F4	4	5	**9**	**F9**	**2**	**2**
5	F5	5	7	**10**	**F10**	**1**	**1**

5 Conclusion

From the research, it can be concluded that the most influenced failure mode at warehouse operation in Indonesian Power Plant to be prioritized is the failure on taken/received material code. The ranking determination of the failure is based on RPN value. There is no classification on ranking for the most influenced failure to be prioritized by FMEA and modified FMEA method. Further research is needed using fuzzy logic modification to minimize errors.

Researchers thank to the support of Industrial Engineering Department, Faculty of Industrial Technology, Universitas Islam Indonesia.

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