The implementation of preventive maintenance using machine damage analysis: a case study of power plant machine

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**Abstract.** Maintenance has an important role in supporting the manufacturing process. The irregular maintenance in the industry can cause downtime and discontinue the production process. The importance of maintenance can be seen in PT PLN Sektor Tello, one of the industries which supply the electricity in Makassar. Since the electricity contributes to the huge impact on the life's sector, there should be preventive maintenance to all of the machine components in order to ensure that the components can run well and reduce the impact. To analyze the PT PLN Sektor Tello machine's performance, the researchers use the Failure Mode and Effect Analysis (FMEA) to identify the type of failures and recommend the maintenance plan. The FMEA's result will be used to calculate the RPN (Risk Priority Number) for each failure and provide the recommendations that will be conducted at maintenance when the RPN's value is equal or more than 125. By using the FMEA, we found three types of machine failures, such as the component's leakage, the machine's knock, and the broken component.

1. Introduction

Maintenance is the process of correcting the failure and improve the performance of the system [1,2]. The maintenance is essential in the industry because of the needs of high-quality performance of automatization and mechanization to support the production process that has been increased through the years. If the machine does not run effectively, the production process will be discontinued immediately. Therefore, the implementation of maintenance of a machine before it is failure becomes a trend in the industry since it can reduce the cost needed for repairing and maintaining the quality of the final product [3].

According to [4], maintenance can be divided into four categories, which are reactive, preventive, predictive, and proactive maintenance. Reactive maintenance is the process of performing or correct the fault in the system after the failure exists. Different from reactive maintenance, preventive maintenance is the process to avoid the failure of the system before the failure exists by doing time-scheduled maintenance. Predictive maintenance is the process of showing the failure of a system before it stops production. Last but not least, proactive maintenance is the process where the maintenance expert does something to solve the problem. From those four types of maintenance, the preventive maintenance commonly applied in many processes since it can minimize the cost needed to repair the system and expedite the production process by keeping the quality and effectiveness of the final product [5–7].

The analysis that will be used when applying the preventive maintenance in this study is Failure Mode and Effect Analysis (FMEA). FMEA is the method designed to identify the cause and effect of
possible failure on the system for a given product or process [8,9]. The FMEA can be used to address the most and less serious concern about the failure and recommend users to do the corrective action appropriately. Thus, it also helps the manufacturers to define which type of maintenance action they will use to minimize the repair time along with its failure’s occurrence.

Practically, the FMEA has been used in many aspects of life: healthiness, manufacturing, and safety. One of the applications in using FMEA in healthiness aspects is using the FMEA analysis to find the causes of the increasing number of NICU because of the Central line-associated bloodstream infections (CLABSIs) over two years periods [8–10]. In here, the FMEA methods are applied and resulted in decreasing the CLABSIs rate from 2.6 to 0.8 per 100-line days and increasing of quality improvement and safety in the NICU. Moreover, the FMEA also can be used in manufacturing to find out the possible failure of the Automated Storage/Retrieval Systems (AS/RS)’s the new design [8].

2. Research Method

This study utilizes preventive maintenance using Failure Mode and Effect Analysis (FMEA) to evaluate the maintenance action needed on PT.PLN Sektor Tello. PT. PLN Sektor Tello is a company that has an important role in supplying electricity that is equal to 197,61, in total. One of the machines that have an important role in producing electricity is a generator.

During the operation, the damage was found in several components of the diesel-electric power generation machine that resulted in considerable losses. Therefore, new preventive maintenance planning is needed to avoid further damage to the machine and to maximize the production process. In this study, the researcher applies quantitative methods—Company survey, observation, interview, and documentation analysis process. Data collection was conducted on (February 2019).

As shown in Figure 1, we use Failure Mode and Effect Analysis (FMEA) to identify the machine component that often experiences damage and also the causes. The outputs of these processes are about types of failures that potentially occur in the production process, the effect of the failure mode, and Risk Priority Number (RPN) in each failure. In FMEA conventional assessment, the RPN value was comprised of three elements, namely the severity of the failure affect (S), Probability of the occurrence of the failure mode (O), and the probability of failure detection (D) [11].

Risk Priority Number is calculated by the following formula [12]:

\[ RPN = S \times O \times D \] ...

S = Total value agreement with the FMEA team about the effect of the unavailability of the spare part.
O = The frequency of the specific failure rate of production activity produces a form of waste.
D = Measurement of the ability to detect or control failures that might occur

Each element is evaluated by a scale of 1 to 10. Therefore, higher value is indicated the higher risk of the failure mode occurrence [11]. In this research, [12] the maximum standard to propose the maintenance action is on ≥ 125, thus, determined based on the multiplication of the mean value of each criterion (Severity, occurrence, and detection) and in accordance with the agreement of the relevant company.
3. Result and Discussion

Based on a case study we conducted at PT PLN Tello Sector, we found that some machines in the PLTD experienced a failure during operation and needed preventive maintenance planning to prevent those failures. Before planning corrective actions, an analysis of the types of failures that often occur along with the effects of failures is carried out using FMEA, as shown in Table 1.

| Item          | Failure Mode                              | Effect Analysis | Cause of Failure                       | Observation                                      | S  | O  | D  | RPN  | Proposed Action                                      |
|---------------|-------------------------------------------|-----------------|----------------------------------------|-------------------------------------------------|----|----|----|------|------------------------------------------------------|
| Diesel        | A fan JCW radiator element is leaking     | Stop operating  | The clutch has worn                    | Visual observation by the operator               | 7  | 6  | 3  | 126  | Radiator element should be replaced                   |
|               | Hard knock onto the cylinder              | Stop operating  | Failure in the lubrication process     | Visual observation by the operator               | 8  | 6  | 3  | 144  | Adjust the Clearance inhaust and exhaust valve        |
|               | The CVS lubricant pipe on the outlet of the engine is leaking | Stop operating  | Leakage on CVS lubricant pipe packaging | Visual observation by the operator               | 8  | 6  | 3  | 144  | Replace the O-ring                                    |
|               | Cooling water jacket pump coupler is broken | Stop operating  | The process is diverted into another pump | Cooling water jacket pump coupler is broken     | 6  | 5  | 4  | 120  | No change                                            |
|               | Leakage on quick lane lubrication        | Stop operating  | O-ring for CVS valve in broken         | Visual observation by the operator               | 8  | 6  | 3  | 144  | Replace the O-ring                                    |

Table 1. FMEA analysis.
The fuel oil booster pump does not operate. Stop operating Fuel filter does not work properly Visual observation by the operator 8 5 3 120 No change
Steam leaking from manhole boiler The operation of MFO is interrupted due to slow steam production Visual observation by the operator 8 3 3 72 No change
Mitsubishi Rocker arm lubricant oil pressure is low Stop operating Filtered element is dirty Parameter control 9 4 4 144 Clean the oil filter
Intercooling radiator fan belt strap comes off Still operating Intercooling radiator fan belt strap comes off Visual observation by the operator 6 4 4 96 No change

Based on the FMEA table above, we can conclude that there are five engine components that must be repaired. The five elements are the leakage of fan JCW radiator, the hard knock of the cylinder, the leakage of the CVS lubricant pipe on the outlet of the engine, Leakage on quick lane lubrication, and the low pressure of rocker arm lubricant oil. All of those components have RPN is more than 126 and need a component's replacement.

4. Conclusion
The objectives of this research are to identify the failures mode and effects of the machine and to recommend an effective maintenance action for PT.PLN Sektor Tello, specifically on SW Diesel and Mitsubishi generator. Based on the above findings, the writers conclude that there is five engine component that must be repaired. Thus components are the leakage of fan JCW radiator, the hard knock of the cylinder, the leakage of the CVS lubricant pipe on the outlet of the engine, Leakage on quick lane lubrication, and the low pressure of rocker arm lubricant oil. As a result of our findings, we recommend PT PLN Sektor Tello to applied 125 work hour (P1) of the weekly maintenance schedule for the hard knock of the cylinder and Leakage on quick lane lubrication, 250 work hours (P2) of the mid-month maintenance schedule for the leakage of fan JCW radiator and CVS lubricant pipe packing, then 1500 work hours (P4) of maintenance for rocket arm lubricant oil pressure, or quarterly maintenance schedule.

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