The strategy improvement of the engine maintenance

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Abstract. PT. A is a company engaged in the manufacture of Crude Palm Oil (CPO) and Palm Kernel Oil (PKO). Constraints faced by PT. A is no planned scheduling of machine maintenance. Therefore, it is necessary to design a maintenance strategy in the form of a machine maintenance schedule to overcome the problem, as well as an analysis of the causes of failure of engine components that are often damaged. This problem is solved by using the Reliability Centered Maintenance (RCM) methods in determining repair priorities so that a more optimal repair plan is obtained. The Pareto diagram is used to determine the most critical machine in the RCM method. The results of the pareto diagram obtained by the screw press machine are the most critical machines. Furthermore, the results of the application of RCM methods obtained components that must be treated regularly (time directed).

1. Introduction

In a company, damage to a production machine is a problem that must be addressed. The high amount of machine damage can cause disruption of the process and the amount of production [1], [2]. For this reason, companies must think about how optimal engine maintenance activities are so that engine damage can be minimized.

With the application of a proper and systematic care policy system, the RCM method can be used to increase efficiency by reducing maintenance costs but still maintaining the value and reliability of assets owned by a company as a strategy in facing a competitive environment [3], [4].

In addition, the RCM method has the advantage of determining maintenance programs that focus on critical components or machines (critical item list) and eliminating unnecessary maintenance activities by determining the optimal maintenance interval [5], [6].

Companies are using machines that operate during 2 working shift. Engine damage often occurred during working hours of the machine, thus the production process is not running. It is necessary for the system maintenance scheduled on machinery/equipment production in the company to to minimize the inhibition of the production process in case of damage.

At present, the types of constraints in production that occur at PT. A is not running smoothly production activities on the production floor due to damage to the production machine so as to inhibit or stop the production process.

So far the system applied in carrying out maintenance activities at PT. A is to do corrective maintenance carried out after the failure / damage to a system. This is of course very risky for the company’s production considering the 24-hour / day operating hours.

This study also uses the Gray Failure Mode Effect and Analysis (GFMEA) method to identify failures of a component that can cause system failure. Thus the damage that occurs can be finalized by knowing the cause of failure of the engine components that are often damaged.

2. Research type

This type of research is included in descriptive research, research that aims to describe systematically, factually, and accurately about the facts and characteristics of an object or a particular population. This research includes the process of data collection, data processing, and problem solving analysis. The results of the study aimed to provide a proposal for the schedule of engine component replacement [7], [8].
3. Method and Discussion

3.1. Reliability Centered Maintenance (RCM)

There are several steps in the RCM stage [9], [10], [11], [12], [13]:

1. Systems Selection and information collection

Based on the results of data collection, the system chosen is a system that has the highest total frequency of damage and downtime criteria shown in Figure 1.

![Diagram Pareo of Machine Breakdown](image)

**Figure 1.** Pareto Diagram Machine Damage PT. A

From the results of the Pareto diagram of machine damage using the 80% -20% principle, it was found that there were 7 types of machines which were damaged up to 80% cumulative, namely Screw Press, Vertical Clarifier, Sludge Saparator, Claybath, Ripple Mill, Oil Purifier and Hoisting Crane. However, the priority of the study was carried out on the machine with the highest frequency of damage, namely the Screw Press machine with a cumulative percent of damage of 15.87%.

2. Defining System Limits

Defining system boundaries is the second step that must be done after system selection. This is done so that the system is considered to have clear boundaries, and does not occur overlapping with other systems. The reasons for defining system boundaries are very important in the analysis of the RCM process, namely:

a. So that there are clear boundaries about what should be involved and not in the system so that the list of identified components becomes clear and does not overlap between the related systems.

b. System boundaries become a very important factor in determining what inputs enter and what outputs come out of the system so that the analysis of the system process takes place accurately.

3. System Description and Function Of Block Diagram

System description and function block diagram is a representation of the main functions of the system in the form of blocks that contain the functions of each sub-system that composes the system. There are several items developed at this stage, namely:

a. System Description

The sub systems contained in this research are as follows:

1) Stacking Unit

   The stacking unit works so that Hydraulic can give the opponent pressure to double screw thrust in the fiber / trunk, with the pressing of the crushing pads by the hydraulic double cone so the oil will come out of the mass pressed through the cylinder press.

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2) Moving Unit
Moving Unit functions as a propeller that will be switched on to activate the hydraulic system, powering or powering the machine into one of the other parts so that the unit can move to produce a rotational or shifting movement.

3) Process Unit
The press machine will separate the oil from the digester and impress it to produce palm oil crude palm oil (CPO) and kernel. This machine works by squatting or chopping palm oil to get dirty or crude palm oil.

Function block diagram is a diagram that gives a clear picture of the structure of the system function. The Screw Press machine function block diagram can be seen in Figure 2.

![Figure 2. Block Diagram Function Machine Screw Press](image)

4. System function and the failure of the function
System function is the expected performance of a system to operate while system failure is the inability of a component / system to meet the expected standard. Data search activity will be more structured and easier to do with function coding and function failure. Function coding and function failure are performed with the following information:
   a. The letters symbolize the operating unit name of the Screw Press machine.
   b. The first number represents the name of the main component of the Screw Press machine.
   c. The second number represents failure of function.

Description of function and failure function at PT. A can be seen in Table 1.

5. Grey Failure Mode and Effect Analysis
System function is the expected performance of a system to operate. RCM defines failure as unsatisfactory or unsatisfactory condition, as its size is the function of the function according to the specified standard performance. One of the steps in RCM in helping to analyze the causes of failure is to use GFMEA.
GFMEA is the process of identifying the failure of a component that can cause the failure of the system's function in the production of palm oil processing. Thus, we will be able to give more treatment to these components by proper maintenance. The Gray Theory application in FMEA was done first by looking for the value of severity, occurrence, and detection. Determination of severity, occurrence, and detection values based on Focus Group Discussion (FGD) results with screw press machine mechanics. Furthermore, it is possible to determine the value of Risk Priority Number (RPN). RPN is the result of mathematical calculation of the effectiveness of severity, the occurrence of causing causes of failure related to the effect (occurrence), and the ability to detect failure before the detection. Results from RPN indicate the priority level of equipment that is considered to be high risk as a pointer towards corrective actions.

The above values are based on the severity, occurrence, and detection scoring tables on the theoretical basis. The determination of Risk Priority Number can be seen in Table 2.
This test resulted in the highest RPN of 216 on the Hydraulic Double Cone component with a form of failure in the form of electromotor burned due to unsuitable pressure. In Gray FMEA the equipment that has the highest RPN will be prioritized in the maintenance activities. The order of the components that has the highest RPN up to the lowest is Hydraulic Double Cone, Van Belt and Gear Box.

6. Logic Tree Analysis

Logic Tree Analysis (LTA) contains information of the number, function failure name, failure component, component function and component damage mode, criticality analysis. Critical analysis puts any component damage into 4 categories:

a. Categories A (Safety problem)
b. Categories B (Outage problem)
c. Categories C (Economic problem)
d. Categories D (Hidden failure)

Four important points in critical analysis are as follows:

a. Evident, namely what the operators know in normal condition, have the system interrupted?
b. Safety, namely whether this damage mode causes safety concerns?
c. Outage, namely does this damage mode result in the whole or part of the machine stalling?
d. Category, namely the categorization obtained after answering the questions posed.

The logic tree analysis of the Screw Press engine can be seen in Table 3.

### Table 1. System Functions and Functional Failures

| System Function Code | Function Failure Code | Function Description or Function Failure |
|----------------------|-----------------------|------------------------------------------|
| A.1.                 | A.1.1.                | Functioning hydraulic can give opponent pressure to the double screw thrust on the fiber / trunk. Experienced damage due to bearing failure due to pressure exceeding 40-50 bar and lack of lubricant. |
| B.2.                 | B.1.1.                | Serves as a drive that will be turned on to activate the hydraulic system. Damage due to improper pressure, exceeding 40-50 bar so that it can cause electromotor to burn. Separating oil from the digester and pressing it to produce CPO and palm kernel. This machine works by squeezing chopped or chopped palm to get dirty or rough palm oil. |
| C.1.                 | C.1.1.                | Has damage such as the occurrence of leeway in rubber due to lack of lubricant. |

### Table 2. Risk Priority Number Table

| No | Parts  | Failure Mode | Failure Causes | Failure Effect | Severity | Occurance | Detection | RP N |
|----|--------|--------------|----------------|----------------|----------|-----------|-----------|------|
| 1  | Gearbox| Broken Gearbox | • Lack of Lubricant • Rupture of the bearing cause of more than 40-50bar pressure | Cannot adjust movement speed | 7        | 3         | 5         | 105  |
### Table 2. Risk Priority Number Table (Continued)

| No | Parts            | Failure Mode                  | Failure Causes                               | Failure Effect       | Severity | Occurance | Detection | RPN |
|----|------------------|-------------------------------|---------------------------------------------|----------------------|----------|-----------|-----------|-----|
| 2  | Hydraulic Double Cone | Broken Hydraulic Double Cone | • Pressure more than 40-50 bar • Burned out Electromotor • Lack of Lubricant | reduced service life | 9        | 6         | 4         | 216 |
| 3  | Van Belt         | Loose Van Belt Rubber         | • Lack of Lubricant • Uneven rubber surface | reduced service life | 9        | 6         | 3         | 162 |

### Table 3. LTA Results Identification Recap at PT. A

| No | Parts            | Failure Mode                  | Evident | Safety | Outage | Category |
|----|------------------|-------------------------------|---------|--------|--------|----------|
| 1  | Gearbox          | Broken Gearbox                | Y       | T      | Y      | B        |
| 2  | Hydraulic Double Cone | Hydraulic Double Cone | Y       | T      | Y      | B        |
| 3  | Van Belt         | Loose Rubber Van Belt         | Y       | T      | Y      | B        |

7. **Action Selection**

The choice of action for RCM must provide clear results. The work done must be able to reduce the number of failures or at least reduce the level of damage due to failure. The selection of actions is based on answering the guiding question (selection guide) that is adjusted to the action selection road map. Based on the previous steps that have been carried out, there are 3 components classified as Time Directed, namely Gearbox, Hydraulic Double Cone, and Van Belt.

3.2. **Critical Component Change Schedule**

To overcome the high number of breakdown machines at PT. A, it is offered a solution for scheduling replacement of critical engine components with Reliability Centered Maintenance method based on historical data on engine component damage [14], [15]. The time interval for the replacement of critical engine components based on the Reliability Centered Maintenance method as shown in Table 4.

### Table 4. Timing Intervals for Replacing the Critical Components of the Screw Press Machine

| No | Component            | MTTF (day) |
|----|----------------------|------------|
| 1  | Gearbox              | 53         |
| 2  | Hydraulic Double Cone | 66         |
| 3  | Van Belt             | 68         |

The MTTF value is a critical component maintenance time plan of the Screw Press machine. The maintenance schedule for each component is based on the MTTF calculation of each component. Where the plan for maintenance of critical components of the gearbox is every 53 days, the hydraulic double cone is 66 days, and the van belt is 68 days. Already able to schedule replacement of critical engine components, calculated reliability of critical engine components. Calculations are carried out based on the distribution patterns that have been selected for each component. The recapitulation of the reliability values on the component replacement interval schedule can be seen in Table 5.
Table 5. The recapitulation of the reliability values on the component replacement interval schedule

| No | Component            | Replacement Interval (day) | Reliability |
|----|----------------------|-----------------------------|-------------|
| 1  | Gearbox              | 53                          | 0.36725     |
| 2  | Hydraulic Double Cone| 66                          | 0.6011      |
| 3  | Van Belt             | 68                          | 0.6011      |

4. Conclusion
The conclusions that can be taken are:
1. Critical machines that are the priority of the research discussion are Screw press machines, which are machines with the greatest frequency of damage. The main source of damage to the screw press is:
   a. Broken bearing as a result of excessive pressure.
   b. Inappropriate pressure on the Hydraulic double cone that can cause electromotor to burn.
   c. Loose Rubber Van Belt which is affected by uneven rubber surfaces.
   d. Lack of lubricant that causes wear
   Screw press machine components that need to be replaced in certain time periods, namely gearboxes, double cone hydraulics and van belts.
2. Distribution patterns of critical components of screw press include: gearbox distribution with weibull distribution, hydraulic double cone components with weibull distribution and van belt components with normal distribution.
3. The analysis of equipment that has the highest to lowest RPN is Hydraulic Double Cone, Van Belt, and Gear Box. Equipment that has the highest RPN will be prioritized in maintenance activities.
4. The engine maintenance strategy in the form of a critical component maintenance for gearbox components is 53 days with a reliability value of 0.36725, hydraulic double cone components are 66 days with a reliability value of 0.6011 and the van belt component is 68 days with a reliability value of 0.6011.

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