The spare part maintenance of cake breaker conveyor with reliability centered spares method

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Abstract. The company that this research conducted is a manufacturing industry that produces CPO. Many machines in the production section need maintenance activities so that existing machines can work without inhibiting the production process. At seed processing station, there is CBC machine that experienced frequent occurrence damage. The machine applies corrective maintenance regardless of reliability machine production components, consequently, often occur sudden machine damage. Calculation of time interval-based maintenance policy scheduled discard task and needs a replacement component (spare part) that should be available are concerned with an optimal using method of Reliability-centered Spares (RCS). Based on the results of the calculations are based on a policy scheduled discard task then obtained a policy to perform maintenance on a screw conveyor components is 91 days, hangers and bearings are 40 days, jig-drilled couplings is 21 days. The result of the method of RCS acquired number of screw conveyor parts needs with this type of repair repairable spare is 3 units for one year, while jig-drilled couplings with this type of repair repairable, need spare part 27 units for a year, as well as the hangers and bearing with this type of repair repairable spare part, needs 21 units for one year.

1. Introduction
The current technological developments in Indonesia are running fast and increasingly sophisticated. So that it can be felt in various activities and daily life, especially in the manufacturing industry. In an effort to use production facilities so that the continuity of production can be guaranteed, it is necessary to plan maintenance activities that can support the reliability of a machine [1]. Machine reliability is one of the most important aspects that can affect the smooth process of production, and the products produced [2]. This reliability can help estimate the chance of a machine component to be able to work in accordance with the desired goals in a certain period. Companies engaged in the processing of palm oil which often experiences high problems in its production machinery. This hampers the course of the production process which results in a decrease in production capacity at the seed processing station which has a role to further process fiber produced from the pressing station. Cake Breaker Conveyor machine (CBC) is one machine that has an important role in the separation of palm kernel and shell. When the CBC machine is damaged, it can be ascertained that the next production process will be disrupted. One type of damage that causes the engine to stop is that there are components that cannot be repaired but must be replaced. Maintenance policy is made with Reliability Centered Maintenance (RCM) and spare parts policy using Reliability Centered Spares (RCS) [3]. Therefore, to solve this

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problem, it is necessary to apply an engine maintenance system using Reliability Centered Spares (RCS) method so that the procurement of spare parts can be optimized to avoid the cessation of the engine and also to reduce excessive inventory costs.

2. Research method
This type of research is descriptive research, which is a type of research that aims to describe systematically, factually, and accurately the facts and characteristics of a particular object or population [4]. The object of the research observed was the Cake Breaker Conveyor machine (CBC) in the process of producing CPO (Crude Palm Oil) at the company.

3. Result and discussion

3.1. Data collection

3.1.1. Collecting data on the damage of CBC machine components
Data collection based on the determination of critical components is chosen from the frequency of the most damage from each component that is on the CBC machine during the 2014-2017 period. Damage frequency data collected based on historical data in the maintenance section are as follows.

| CBC Component          | Damage Frequency | Percentage (%) | CBC Component          | Damage Frequency | Percentage (%) |
|------------------------|------------------|----------------|------------------------|------------------|----------------|
| Discharge Spouts       | 0                | 0%             | Clamps and Shrouds     | 1                | 1%             |
| Conveyor Screw         | 11               | 10%            | Flange                 | 1                | 1%             |
| Hangers and Bearing    | 28               | 21%            | Jig-Drilled Couplings  | 53               | 55%            |
|                        |                  |                | Supporting Feeds and Saddle | 6            | 6%             |
| Trough Ends            | 6                | 6%             |                        |                  |                |
| Total Damage           |                  |                |                        |                  |                |
| Total Frequency        |                  |                |                        |                  |                |

3.1.2. Testing the time to repair distribution
Our modeling approach is to consider the time to fix (TTR) as a random variable depending on the many parameters that characterize the subsystem involved. [6] Testing the suitability of the distribution selected using Minitab software which can be seen in the following table.

| Component              | Distribution | Anderson Darling Value | P-Value | Chosen Distribution |
|------------------------|--------------|------------------------|---------|---------------------|
| Conveyor Screw         | Normal       | 0,226                  | 0,76    | Normal              |
|                        | Exponential  | 2,678                  | 0,003   |                     |
|                        | Weibull      | 0,253                  | 0,250   |                     |
| Hangers and Bearing    | Normal       | 0,182                  | 0,903   | Normal              |
|                        | Exponential  | 6,689                  | 0,003   |                     |
|                        | Weibull      | 0,204                  | 0,250   |                     |
| Jig-Drilled Couplings  | Normal       | 0,732                  | 0,053   | Weibull             |
|                        | Exponential  | 7,003                  | 0,003   |                     |
|                        | Weibull      | 0,448                  | 0,250   |                     |
3.1.3. Determination of time to repair distribution parameters representing
Determination of parameters based on the TTR distribution that represents can be seen in the following table.

| Component               | Distribution | Parameter | M       | Σ       | P       |
|-------------------------|--------------|-----------|---------|---------|---------|
| Conveyor Screw          | Normal       |           | 5,81818 | 1,67752 | 0,95302 |
| Hangers and Bearing     | Normal       | M         | 5,92857 | 1,78002 | 0,98264 |
| Jig-Drilled Couplings   | Weibull      | H         | 9,36445 | 2,11346 | 0,98847 |

3.1.4. Calculation of Mean Time to Repair (MTTR)
The evaluation of realistic MTTR for each alternative design is, therefore, a necessity related to the protected design process [7]. Calculations are made based on the selected distribution. MTTR calculation results are as follows.

| Component               | Distribution | Mean Time to Repair |
|-------------------------|--------------|---------------------|
| Conveyor Screw          | Normal       | 5,82                |
| Hangers and Bearing     | Normal       | 5,93                |
| Jig-Drilled Couplings   | Weibull      | 8,29                |

3.1.5. Testing of time to failure (TTF) distribution match
Testing the suitability of the distribution selected using Minitab software with the following results.

| Component               | Distribution | Anderson Darling Value | P-Value | Distribution |
|-------------------------|--------------|------------------------|---------|--------------|
| Conveyor Screw          | Normal       | 0,256                  | 0,641   | Normal       |
|                         | Exponential  | 2,642                  | 0,003   |              |
|                         | Weibull      | 0,309                  | 0,250   |              |
| Hangers and Bearing     | Normal       | 1,164                  | 0,005   | Weibull      |
|                         | Exponential  | 1,378                  | 0,04    |              |
|                         | Weibull      | 0,396                  | 0,250   |              |
| Jig-Drilled Couplings   | Normal       | 0,597                  | 0,116   | Weibull      |
|                         | Exponential  | 5,899                  | 0,003   |              |
|                         | Weibull      | 0,355                  | 0,250   |              |
3.1.6. Determination of mean time to failure
Calculations are made based on the selected distribution. MTTF calculation results are as follows.

| Subsystem               | Distribution | Mean Time to Failure |
|-------------------------|--------------|----------------------|
| Conveyor Screw          | Normal       | 2909.3               |
| Hangers and Bearing     | Weibull      | 1280.74              |
| Jig-Drilled Couplings   | Weibull      | 676.78               |

MTTF of such a system has been obtained using the renewal theory in the condition that the probability distributions about failure and repair times have the respective explicit functions.[8] Maintenance time intervals for scheduled discard task policies are obtained through half of the MTTF (Mean Time to Failure) value with a working day per month which is 24 days and working hours which is 16 hours.[9] Following is the calculation of maintenance time intervals based on scheduled discard task policy for screw conveyor components, hangers and bearings, and jig-drilled couplings, as shown in the following table.

| Component               | Mean Time to Failure (MTTF) | Maintenance Interval (Hours) | Maintenance Interval (Months) | Maintenance Interval (Days) |
|-------------------------|-----------------------------|-------------------------------|------------------------------|----------------------------|
| Conveyor Screw          | 2909.3                      | 1454.65                       | 3.79                         | 91                         |
| Hangers and Bearing     | 1280.74                     | 640.37                        | 1.67                         | 40                         |
| Jig-Drilled Couplings   | 676.78                      | 338.39                        | 0.88                         | 21                         |

3.1.7. Calculation of non-repairable needs
Non-repairable is a condition when repairing components is difficult to do and is not possible or when repair costs are greater than the cost of purchasing components, including non-repairable components are hangers and bearings. [10-17] Calculations for "λ" t use the following formula.

\[
\lambda t = \frac{A \times n \times M \times t^3}{MTTF} = \frac{4 \times 1 \times 384 \times 1}{1280.74} = 14.39
\]  

so that for hangers and bearing needs are as follows:

| N fact(n-1) | exp(\(\lambda t\)) | \(\lambda^n/n!\) | P    | P (%) | N fact(n-1) | exp(\(\lambda t\)) | \(\lambda^n/n!\) | P    | P (%) |
|-------------|---------------------|-------------------|------|-------|-------------|---------------------|-------------------|------|-------|
| 0           | 1 5.62E-07          | 1 5.62E-07        | 0%   | 32%   | 12 479001600 | 5.62E-07          | 164808.9          | 0.321030 | 32%   |
| 1           | 1 5.62E-07          | 14.3916           | 0%   | 32%   | 13 6227020800| 5.62E-07          | 182451.3          | 0.423582 | 42%   |
| 2           | 2 5.62E-07          | 103.5594          | 0%   | 32%   | 14 87178E+10 | 5.62E-07          | 187555            | 0.529003 | 53%   |
| 3           | 6 5.62E-07          | 496.796           | 0%   | 32%   | 15 13077E+12 | 5.62E-07          | 179948.1          | 0.630148 | 63%   |
| 4           | 24 5.62E-07         | 1787.425           | 0%   | 32%   | 16 20923E+13 | 5.62E-07          | 161859.1          | 0.721126 | 72%   |
| 5           | 120 5.62E-07        | 5144.791          | 0%   | 32%   | 17 35569E+14 | 5.62E-07          | 137024.4          | 0.798144 | 80%   |
| 6           | 720 5.62E-07        | 12340.32          | 0%   | 32%   | 18 64024E+15 | 5.62E-07          | 109555.8          | 0.859723 | 96%   |
| 7           | 5040 5.62E-07       | 25371.02          | 0%   | 32%   | 19 1.216E+17 | 5.62E-07          | 82983.44          | 0.906366 | 91%   |
| 8           | 40320 5.62E-07      | 45641.28          | 0%   | 32%   | 20 2.4329E+18 | 5.62E-07          | 59713.32          | 0.939930 | 94%   |
| 9           | 362880 5.62E-07     | 72983.57          | 0%   | 32%   | 21 5.1091E+19 | 5.62E-07          | 40922.46          | 0.962932 | 96%   |
| 10          | 3628800 5.62E-07    | 105035.2          | 0%   | 32%   | 22 1.124E+21 | 5.62E-07          | 26770.03          | 0.977978 | 98%   |
| 11          | 39916800 5.62E-07   | 137420.7          | 0%   | 32%   | 23 2.28395   | 5.62E-07          | 105035.2          | 0.977978 | 98%   |
Based on the results of calculations in table 8, the number of spare requirements recommended for companies to be able to meet 95% availability of spare hangers and bearings for a year is 21 units.

3.2. Calculation of repairable needs
Included in the repairable component are jig-drilled couplings and screw conveyors. The formula used is as follows.

a. Needs Calculation of conveyor screw

\[ \lambda_t = \frac{A \times N \times M \times MTTR}{MTTF} \]

\[ \lambda_t = \frac{1 \times 1 \times 364 \times 5.8}{23053} = 0.77 \]

Table 9. Screw conveyor calculations

| n-1 | exp(\(\lambda_t\)) | fact(n-1) | \(\lambda_t(n-1)/(n-1)!\) | P | P |
|------|-----------------|----------|----------------|---|---|
| 0    | 0.46            | 1        | 1.00            | 0.47 | 47% |
| 1    | 0.46            | 1        | 0.77            | 0.82 | 82% |
| 2    | 0.46            | 2        | 0.29            | 0.96 | 96% |

Based on the results of calculations in table 9, the number of spare requirements recommended for companies to meet 95% availability of screw conveyors for a year is 3.

b. Calculation of need for jig-drilled couplings

\[ \lambda_t = \frac{A \times N \times M \times MTTR}{MTTF} \]

\[ \lambda_t = \frac{1 \times 1 \times 364 \times 8.25}{6757.8} = 18.82 \]

The number of spare requirements recommended for companies to meet 95% availability of spare jig-drilled couplings for a year is 27 units.

4. Conclusion
The conclusion of the research that has been done is as follows:

- Based on the results of the determination of critical components, it is known that the cake breaker conveyor machine has eight components, judging from the frequency of the most damage during 2014-2017, there are three critical components namely screw conveyors, hangers and bearings, and jig-drilled couplings.
- Based on the results of determining the maintenance time interval based on scheduled discard task policy, the maintenance of the screw conveyor component is 91 days, hangers and bearings are 40 days, and the jig-drilled couplings is 21 days.
- Based on the results of calculations using reliability centered spares calculation, the number of critical components available in the company is needed for one year, namely for components of screw conveyor components are 3 units, for hangers and bearings is 21 units, and jig-drilled couplings are 27 units.
- Data processing results that have been carried out during the research can be proposed for companies that do not have a fixed machine maintenance schedule in the form of periodic machine component changes so that there will be no sudden engine failure as often happens to the company and avoid the possibility of occurrence delay when replacing engine components that are damaged due to unavailability of replacement components.
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