Hoist Tulangan Machine Maintenance Design Using Lean Maintenance Method (Case Studi of PT. XYZ)

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Abstract. PT. XYZ is a company engaged in manufacturing concrete. There are many machines that used in this company, one of them is the Reinforcement Hoist machine. The Reinforcement Hoist machine is the engine with the highest downtime on line 8 during 2019 with 90 hours. The maintenance system that applied in this company is corrective maintenance. To implement a preventive maintenance system, researcher has used the Lean Maintenance method to find the MTTF value for each component and analyzing maintenance activities by Maintenance Value Stream Mapping (MVSM). The purpose of this research was to determine the critical components of the Reinforcement Hoist machine using FMEA, determine the reliability value of machine using RBD, determine preventive scheduling using selected distributions, and calculate maintenance efficiency using the Lean Maintenance method. From the results of the FMEA critical components are the Gearbox and End Carriage components. The Reliability Value of the Reinforcement Hoist engine is 85.69% with MTTF Gearbox component every 3 days and the End Carriage component every 6 days. The results of the Maintenance Efficiency of the Gearbox component are 49.59% and the End Carriage component is 61.35%

Keywords: Lean Maintenance, MVSM, RBD

1. Introduction

In the current industrial competition in Indonesia, companies are required to be able to utilize the resources in the company consisting of human resources, investments, materials, methods, both effective and efficient machines to support the smooth production system in the company. The production system is a collection of sub-systems that are interrelated with the goal of transforming
production inputs into production outputs (Ginting, 2007).

Care carried out in the industry is one important factor in supporting production processes that have a competitive edge in the market. Therefore, the production process must be supported by equipment that is ready to work at any time and reliably. To achieve this, the equipment supporting the production process must be adjusted according to the plan (Sianturi, 2014).

So that the machine can be maintained by performing maintenance on the machine, both preventive and periodic maintenance. However, it does not rule out the possibility in a machine that can cause damage to unexpected components, or can’t be predicted. This can lead to increased downtime or loss of time caused by the replacement of damaged components while the production process is running. In reducing machine downtime, one strategy is to use the concept of lean thinking in all maintenance or repair activities because it can reduce waste and downtime that occurs.

Based on the above explanation, it is necessary to carry out repairs made by the engine so that it critically reduces downtime. To overcome these problems, the need to do an analysis to make improvements to the company by using the Lean Maintenance method. This method helps reduce downtime and analyzes the efficiency of engine maintenance to make it more optimal so that the machine works better.

2. Theory

2.1 Maintenance
Maintenance is the probability that a component or system that is damaged will be repaired within a certain period of time, where maintenance is carried out in accordance with the proper procedure (Ebeling, 1997)

2.2 Lean Maintenance
Lean maintenance is defined as the philosophy of a maintenance activity that produces the desired maintenance result using the fewest amount of input possible (Levit, 2008). According to Mostafa, et al (2015), lean maintenance adopts lean principles into Maintenance, Repair, and Overhaul (MRO) operations. Lean maintenance is a term used by companies that start trying to combine lean manufacturing techniques with maintenance or maintenance activities.

2.3 Failure Mode Effect Analysis (FMEA)
According to N.B Puspitasari (2014), Failure Mode and Effect Analysis (FMEA) is a methodology used to evaluate failures occurring in a system, design, process, or service (service).

2.4 Reliability
Reliability is defined as the probability that a component, equipment, machine, or system will continue to operate properly by the expected function within a specified time interval.

2.5 Reliability Block Diagram (RBD)
According to Ebeling (1997) Reliability Block Diagram is a method for analyzing system reliability with availability on large and complex systems after using system blocks. RBD can be arranged in series or parallel series or a combination of both.
2.6 Maintenance Value Stream Mapping (MVSM)
According to Kannan (2006), Maintenance Value Stream Mapping (MVSM) is a method used to describe the flow of maintenance activities developed from Value Stream Mapping (VSM) to identify waste.

3. Methodology
This research was conducted at PT. XYZ, one of concrete manufacturing companies in Indonesia which the field located in Bogor. Data processing is carried out in several stages as follows

3.1 Identification of problems
The topic of the problem to be discussed in this study is to optimize the scheduling of engine maintenance by using the value of reliability and optimizing the efficiency of component repairs. Based on the activities of the production process, there is a high number of downtime on the machine components so that the production process stops. In this study, data retrieval is done by looking at the company's breakdown history, which then selects components using the results of the Failure Mode and Effect Analysis.

3.2 Method of collecting data
The steps involved in collecting this data are as follows:
1. Identifying the production process at PT XYZ.
2. Collecting relevant and detailed data based on engine breakdown at PT XYZ. Data collected consists of:
   a. Primary data is data obtained directly through interviews with employees in the company.
   b. Secondary data is data that is collected, processed, and presented by other parties. In this study, secondary data is taken from the company's history data in engine maintenance and breakdown in 2019 at PT XYZ.

3.3 Data processing Method
The steps taken for this research to use the Lean Maintenance method are as follows:
   a. The system selection and data collection are done by looking at the biggest downtime of the machines on the production floor.
   b. In FMEA, an analysis of components that have experienced functional failure is carried out to determine the cause and impact of the failure mode.
   c. Determine the critical components by looking at the highest RPN calculation results to find out the critical components.
   d. Perform calculations and analysis of damage data on engine components, by calculating the Time to Failure (TTF) of critical components on critical machine types. The data used to calculate the date, time of the start of damage, and date and time of completion of repairs.
   e. Calculate Index of Fit, Goodness of Fit, parameter estimation, and calculate MTTF values
   f. Calculate maintenance time intervals and reliability,
   g. Calculating machine reliability values using the RBD (Reliability Block Diagram) method
   h. Calculate the efficiency of the repair process using MVSM
4. Result and Discussion

Discussions in this research include determining critical components with FMEA, calculating TTF values of critical components, calculating the index of fit, goodness of fit, determining component parameters, calculating component reliability values, calculating the value of the system or machine reliability, calculating the value of repair efficiency using MVSM.

Table 1. FMEA Worksheet

| No. | Machine Component | Function Failure | Failure Mode | Failure Effect | S | O | D | RPN |
|-----|-------------------|------------------|--------------|----------------|---|---|---|-----|
| 1   | Hoist Motor       | The motor is on fire | The collector gets off track so it doesn't get electric current | Host does not move right and left | 10 | 2 | 1 | 20 |
| 2   | Gearbox           | As the gearbox is broken | Overloaded and long production time | The gearbox is not running or the hoist will not be able to lift the product | 10 | 6 | 2 | 120 |
| 3   | Push Button       | The button doesn't work | Electric current overload | Function Upon the Hoist does not work | 10 | 2 | 2 | 40 |
| 4   | End Carriage      | Motor End Carriage caught fire | Other usage causes the motor to overheat | Ports can't move | 10 | 3 | 2 | 60 |
| 5   | Lifting Limit Switch | Short circuit | There is a leakage current so the Switch hangs | Host does not move right and left | 10 | 2 | 1 | 20 |
| 6   | Hook Block        | Hook rusty | Overloaded production | Hook to be saggy and eventually break | 10 | 2 | 2 | 40 |
| 7   | V Belt Hoist      | V belt is broken and broken | V belt is worn or eroded | Portal will not move due to the lack of rotation of the motor End Carriage | 10 | 2 | 2 | 40 |
| 8   | Motor Traversing  | The motor is on fire | Collector gets off track so it doesn't get electric current | The function of the hoist to pull up / down does not work | 10 | 2 | 2 | 40 |
| 9   | Power Supply      | Collector off track | Copper in worn collector | Hoist cannot function | 10 | 2 | 2 | 40 |
| 10  | Travel Limit Switch | Short circuit | The switch is exposed to water during production | Hoist cannot function | 10 | 2 | 1 | 20 |

From the calculation of the RPN, it was found that the largest RPN value was the Gearbox component and End Carriage component with RPN values of 120 and 60, respectively.

Table 2. Matching Test Results for Time Distribution Data between Damages, Parameters, and MTTF

| Machine Component | Distribution (TTF) | Parameter | MTTF (Hours) |
|-------------------|-------------------|-----------|--------------|
| Hoist Tulangan    | Normal            | \( \beta = 0.002 \) \( \frac{1}{\sigma} = 785.5 \) | 785.5 |
|                   | weibull           | \( \beta = 0.959 \) \( \frac{1}{\theta} = 1884.07 \) | 1917.184 |

After doing a goodness test using Minitab 16 software, it is known that the inter-time damage data on Gearbox components follow the Normal distribution. Where the parameters obtained for the Gearbox component values \( \beta = 0.002 \) and \( \sigma = 785.5 \). The MTTF Gearbox component results are 785.5, which means the average time between Gearbox component damage is 785.5 hours.

While the inter-time damage data on the End Carriage component follows the Weibull distribution. Where the parameters obtained for the End Carriage component values \( \beta = 0.959 \) and \( \theta = 1884.07 \).
1884.07. The results obtained by the End Carriage component MTF of 1917,184, which means the average time between the damage of the End Carriage component is 1917,184 hours.

The following is a recapitulation of the calculation of the reliability value calculation.

| Component       | Before the Preventive Maintenance | After the Preventive Maintenance | Increased Reliability |
|-----------------|----------------------------------|----------------------------------|-----------------------|
|                 | T (Hours) | Reliability | T (Hours) | Reliability |                        |
| Gearbox         | 785.50    | 50%         | 68.334    | 92.43%      | 42.43%                 |
| End Carriage    | 1884.07   | 36.79%      | 134.503   | 92.71%      | 55.92%                 |

From the data above, the MTTF value obtained before the preventive maintenance of the Gearbox component is 785.5 hours with a reliability value of 50% and the End Carriage component of the MTTF value of 1884.07 hours and reliability of 36.78% 47.37%.

Then the MTTF value after preventive maintenance Gearbox components is 68.333 hours with a reliability value of 92.43% and End Carriage components the value of MTTF is 134.503 hours and reliability is 92.71%.

After the component reliability values are calculated, the next step is to calculate the reliability value of the engine (engine) of the Reaction Hoist. The following is the RBD calculation before and after preventive maintenance.

| Component       | Before the Preventive Maintenance | After the Preventive Maintenance |
|-----------------|----------------------------------|----------------------------------|
|                 | Reliability | RBD | Reliability | RBD |
| Gearbox         | 36.79%       | 18.40% | 92.71%       | 85.69% |
| End Carriage    | 50%           | 92.43% |

Based on the table above Ranganese Hoist machine RBD value of 18.40% means reliability < JPIM that is 85%, after doing preventive maintenance reliability value obtained by 85.69% means reliability > JPIM and indicates that the scheduling of preventive maintenance is optimal.

Next, calculate the MVSM value for the two critical components. The following are the results of the MVSM component calculation.

| No  | Improvement Plan | Gearbox | End Carriage |
|-----|------------------|---------|--------------|

Table 3. Comparison of the value of reliability before and after preventive maintenance

Table 4. Comparison of RBD Reinforcement Hoist Machines before and After Preventive Maintenance

Table 5. Comparison of Current MVSM with Future MVSM Gearbox Components and End Carriage
| Component               | Current | Future | Current | Future |
|-------------------------|---------|--------|---------|--------|
| Equipment Breakdown     | 15      | 10     | 10      | 3      |
| Communication Problems  | 30      | 100    | 30      | 5      |
| Identification of problems | 22      | 5      | 15      | 12     |
| Resource Identification | 15      | 7      | 15      | 5      |
| Allocate resources      | 15      | 5      | 15      | 8      |
| Prepare work to be done| 120     | 120    | 100     | 100    |
| Make improvements       | 30      | 30     | 30      | 30     |
| After the engine is repaired | 30      | 30     | 30      | 30     |
| Completed work          | 247     | 187    | 215     | 163    |
| MTTO                    | 97      | 37     | 85      | 33     |
| MMTR                    | 120     | 120    | 100     | 100    |
| MTTY                    | 30      | 30     | 30      | 30     |
| Value Added Time        | 120     | 120    | 97      | 187    |
| Non-Value Added Time    | 127     | 67     | 517     | 192    |
| Maintenance Efficiency  | 48.58%  | 64.17% | 46.5%   | 61.35% |

Based on the above calculation results, the efficiency value of the improvement of the Gearbox component initial efficiency value is 48.58% and the proposal has increased to 64.17%, while the End Carriage component has an initial efficiency value of 46.51% and the proposed efficiency value of 61.35%

The following is a comparison of the results of hypothesis testing from MVSM values for the two critical components.

| Component      | Kolmogorov Smirnov (α= 0.05) | Paired Sample T-Test |
|----------------|------------------------------|----------------------|
| Gearbox        | 0.2                          | 2.913                | 0.027               |
| End Carriage   | 0.065                        | 2.974                | 0.025               |

Based on the table above the two MVSM proposals for both components are declared valid because in the Kolmogorov test both components have α> 0.05 and in the Paired Sample T-Test the value of T count> T table. Where each T value is 2.913> 2.7 for Gearbox components and 2.974 > 2.7 for End Carriage components.

5. Conclusion

Based on the results of the analysis and discussion, it can be concluded as follows.

1. After calculating the FMEA critical components on the Reinforcement Hoist machine are the
Gearbox and End Carriage components with RPN of 120 and 60, respectively.
2. The reliability value of the machine after doing preventive maintenance is 85.69%
3. Maintenance rescheduling is done with maintenance time intervals of 68.333 hours or 3 days for Gearbox components and 134.503 hours or 6 days for End Carriage components
4. After doing the MVSM calculation the percentage of efficiency values is 64.17% for the Gearbox component and 61.35% for the End Carriage component.

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