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Machine Maintenance Scheduling with Reliability Engineering Method and Maintenance Value Stream Mapping

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Abstract. Corrective maintenance i.e replacing or repairing the machine component after machine break down always done in a manufacturing company. It causes the production process must be stopped. Production time will decrease due to the maintenance team must replace or repair the damage machine component. This paper proposes a preventive maintenance's schedule for a critical component of a critical machine of an crude palm oil and kernel company due to increase maintenance efficiency. The Reliability Engineering & Maintenance Value Stream Mapping is used as a method and a tool to analize the reliability of the component and reduce the wastage in any process by segregating value added and non value added activities.

1. Introduction

Due to the increasing satisfying customer's need in manufacturing, the company must make continuous improvement to keep the company's product quality requirement. Good quality products and can meet the needs and the desires of consumers is a goal of all corporate. Achieving that, manufacturing companies are focused to optimize their production [1, 2]. The life time of using machinery can be extended through scheduled maintenance activities. The maintenance is used for several actions taken to keep the machine's condition as before or fix it until a condition that is qualified. Pressing the delay of completion of work, increase production efficiency, and prevent the decrease in production volume is one of the benefit of maintenance. It is important for the company to further increase the efficiency of its operations. Through good planning and maintenance, the machine damage can be minimized. By a good maintenance scheduling, machine will always be in ready condition. If machine maintenance is done regularly, it is easier to predict the possibility of future damage. This can be reduce losses due to non-functioning of production equipments.

The high downtime is due to the industry using corrective maintenance [3]. If this method is applied as the maintenance strategy, it will result in the high impact of unscheduled maintenance activities of replacement components. Of course it will cause the machine to stop operating at the time of production process takes place. This leads to a loss of production process time when there is a repair process of machine components [4, 5].

The observed factory maintenance system is still corrective maintenance. Due to that situation, it is important to apply preventive maintenance. Scheduled maintenance planning to perform component replacement so that the machine can be used without any damage during production process [6, 7].

The reliability of the machines and the prevention of machinery from breakdown will assist the smoothness of production. One of definition of system reliability is the capability of the system performing its intended function by utilizing probabilistic expressions, like as the probability that the system will fail in a certain time, the expected period of time to break down and the expected number of failures for a certain period [8].

It must be known that reliability analysis is conducted and then the results are presented and also reported to the leader. System Reliability analysis has purposes that all the aproximation process of the system's probability will be able to achieve its function. Reliability of system's part affected by the main of system reliability [9].

Value Stream Mapping (VSM) as a tool has been widely used in various research and applications in the real world. Some development from VSM is energy/environmental VSM, sustainable VSM, quality VSM and VSM 4.0 [10-13]. Widely application of VSM i.e.: automobile, camshaft, water heater manufacturing, process industry, and coffee industry. VSM also applicated in various support function as well sales process, truck transportation, supply chain of cottonseed industry, electrical manufacturing service, healthcare, project management and new product development [14]. It also used for residential construction [15].

It is applied for global system of observations. In Indonesia, previous research about maintenance VSM had been done. The result of both researches is conduct increasing the maintenance efficiency [16, 17].

In this paper, specifics VSM applications in the field of maintenance is used and there for it called Maintenance Value Stream Mapping. It's focus on repair and maintenance of the critical component of critical machine. The goal of this research is to design preventive maintenance machine system with Reliability Engineering and Maintenance Value Stream Mapping (MVSM). Benefits of this research are the company can eliminated non value activities in maintenance, has a scheduled calendar for critical component that observed and increasing it's maintenance efficiency.

2. Methods

A descriptive research is applied, which aim to represent facts and properties of an object. The result is to give the proposal of replacement schedule of the machine component. The method begins with data collection, i.e. data collected from company documentation (machine downtime and breakdown, the frequency of damage, interval damage).

Data collected from direct observation and interview with the head of maintenance. All of that data is important to applicative the method. Further testing of distribution, parameters, and Mean Time To Failure (MTTF) values, and calculation of maintenance efficiency at MVSM.

VSM contains all non value added and value added activities. The objective of VSM is to eliminate wastes [18]. Value Stream Mapping (VSM) method is very effective to redesign of value streams. As a tool VSM help us to understand product's flow activity. By analizing the difference between the current and the future state , the performance of the system could be achieved [19].

The idea of Mean Maintenance Lead Time (MMLT) is being used for maintenance measurement. One of MMLT defenition is the time between analizing the need for maintenance on a particular component to the actual performance of such maintenance and the repair of the component [20]. MMLT has the maintenance activities into account from an operational level. It is a useful tool to analize the maintenance system and activities. The schema of MMLT is shown in Figure 1.

MMLT is given by the following equation:

$$MMLT = MTTO + MTTR + MTTY \tag{1}$$

Where,
MTTO = Mean time to organize (Time required to distribute tasks to initiate the maintenance repairs)
MTTR = Mean time to repair (Time required to repair the component)
MTTY = Mean time to yield (Time required to yield a good component after repair)

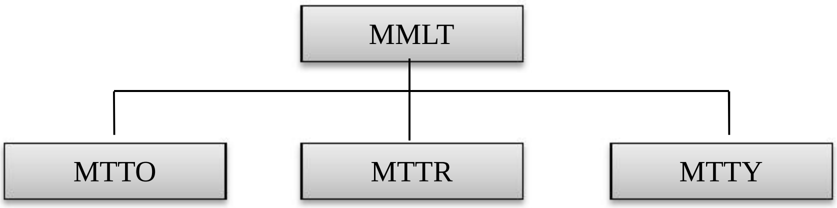

Figure 1. Schema of MMLT.

Within the MMLT schema, the only period component that adds value to the maintenance operations is MTTR, since this is the only period component that contains the actual performance of the maintenance repair task. The other period components MTTO and MTTY are non-value added time. Hence value added time and non value added time are given by,

Value added time	=	MTTR	(2)
Non-value added time	=	MTTO + MTTY	(3)

Maintenance Efficiency is calculated as the percentage of MMLT that is happen on repairing the component.

$$\%\ Maintenance\ Efficiency\ = \frac{V \quad A \quad Ti}{M \quad (M \quad M \quad L \quad Ti \quad)}\ x\ 100\% \qquad (4)$$

3. Results and Discussion

Based on historical data for July 2016 - June 2017 period, in Figure 2 we can see machine's damage frequency. *Screw Press* machine have the highest damage frequency. In Figure 3 we can see Screw Press's component damage frequency. The highest frequency of component damage is *Left Handed Shaft*. So the observed object is *Left Handed Shaft* as a critical component of *Screw Press* machine.

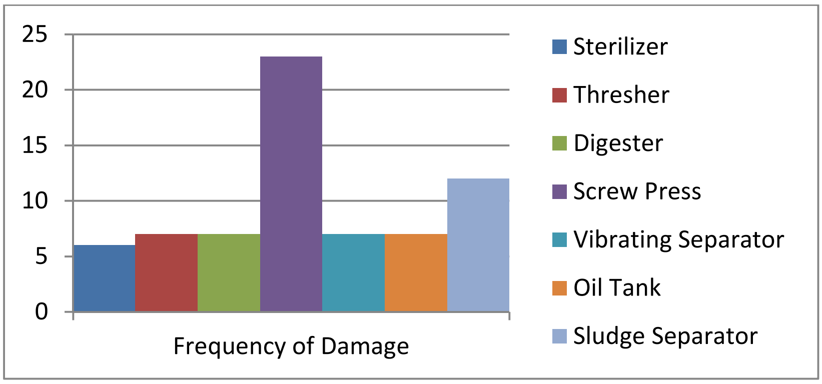

Figure 2. Machine's damage frequency.

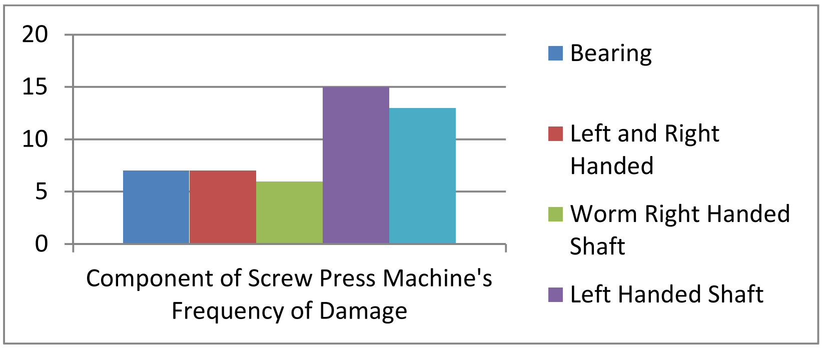

Figure 3. Component of screw press's damage frequency.

3.1. Testing distribution

The first step in the Reliability Engineering Method is testing the distribution of critical machine component. The results of the selected distribution pattern test for *Left Handed Shaft* is Log normal.
The preferred distribution pattern is the distribution that gets the largest Index of Fit (Correlation Coefficient) value.

3.2. Calculation of parameters and MTTF machine components

Calculating MTTF (Mean Time To Failure) is used as a parameter for determining the replacement of machine components. The result of MTTF calculation, hence got the interval of change of *Left Handed Shaft* is 64 days. It means that after using that part for 64 days, *Left Handed Shaft* must be replaced [21].

3.3. Reliability calculation on component replacement interval schedule

The calculation of the reliability value of the critical machine component on the proposed replacement schedule is used to determine the reliability value of the machine components when the proposed component replacement schedule is performed [8, 9]. Reliability calculation for *Left Handed Shaft* is 0,2622. It means that reability of *Left Handed Shaft* too small and if not replaced, the *Screw Press* machine will breakdown because it's component broke. Component *Left Handed Shaft* should to be replaced after 64 days of using. Schedule of replacing *Left Handed Shaft* component for August 2017 - July 2018, can be seen in Table 1.

Table 1. Schedule of replacing component *Left Handed Shaft*

No	Schedule of Replacing
1	24th August 2017
2	27th October 2017
3	30th December 2017
4	5th March 2018
5	8th May 2018
6	11st July 2018

3.4. Comparison of activities of Left Handed Shaft for current state map with future state map.

The comparison can be seen in Table 2.

Table 2. Comparison of activities current state map dan future state map for *Left Handed Shaft*

Current State Map	***Future State Map***
Equipment breakdown	*Equipment breakdown*
Communicated the problem	*Communicated the problem*
Delay, Because no maintenance team	*Indentification of problem*
Indentification of problem	*Indentification of the manpower*
Indentification of the manpower	*Allocated of the manpower*
Delay of no component available	*Preparing work to be done*
Allocated of the manpower	*Maintenance*
Preparing work to be done	*Running to machine after repair*
Maintenance	
Running to machine after repair	

From Table 2 for future state map, non value activities such as delay because no maintenance team and delay of no component available that shown in current state map should be eliminated by allocated of the manpower and preparing stock of components [14, 17, 20].

3.5. Calculation of maintenance efficiency on MVSM

Calculation of maintenance efficiency on MVSM could be done by calculating the value of MMLT based on MTTO, MTTR and MTTY [14, 20]. The comparison of MTTO, MTTR and MTTY value for Current and Future State Map can be seen in Figure 4.

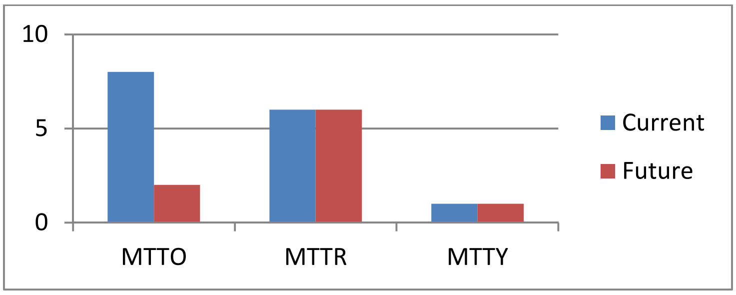

Figure 4. The comparison of MTTO, MTTR and MTTY value for current and future state map.

With this equation:

$$\% \; Maintenance\ Efficiency = \frac{V \quad A \quad Ti}{M \quad (M \quad M \quad L \quad Ti \;)} x\ 100\%$$

The value of % Maintenance Efficiency can be calculated. The comparison Maintenance Efficiency of Current State Map with Future State Map for *Left Handed Shaft* component can be seen in Figure 5.

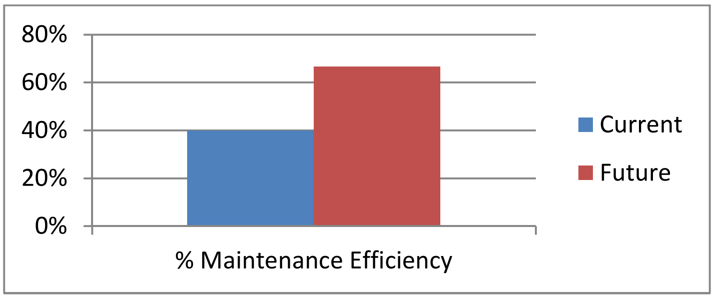

Figure 5. The comparison maintenance efficiency of current state map with future state map for *Left Handed Shaft* component.

4. Conclusions

Mapping activity based on the maintenance activities in terms of the components of MMLT, namely, MTTO, MTTR, and MTTY, Non-Value added time, and Value added time. Maintenance Value Stream Mapping (MVSM) resulted in the percentage of maintenance efficiency for critical component analyzed is increased. This increase is derived from the comparison of current state map application value to development with future state map. The percentage of maintenance efficiency in future state map for *Left Handed Shaft* is 66,66% increased from maintenance efficiency in current state map (40 %). Based on calculation of Mean Time To Failure is 64 days with Reliability value 0.2622 , the schedule of replacing **c**omponent *Left Handed Shaft* for period August 2017 – July 2018 are 24th August 2017, 27th October 2017, 30th December 2017, 5th March 2018, 8th May 2018 and 11st July 2018. From this schedule, preventive maintenance will be applied in this manufacturing company. The whole step for this critical component *Left Handed Shaft* should be done for all components and machines in this manufacturing company due to apllied preventive maintenance.

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