IOP Conf. Series: Materials Science and Engineering **309** (2018) 012128 doi:10.1088/1757-899X/309/1/012128

Design of preventive maintenance system using the reliability engineering and maintenance value stream mapping methods in PT. XYZ

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Abstract. PT. XYZ is a company owned by non-governmental organizations engaged in the field of production of rubber processing becoming crumb rubber. Part of the production is supported by some of machines and interacting equipment to achieve optimal productivity. Types of the machine that are used in the production process are Conveyor Breaker, Breaker, Rolling Pin, Hammer Mill, Mill Roll, Conveyor, Shredder Crumb, and Dryer. Maintenance system in PT. XYZ is corrective maintenance i.e. repairing or replacing the engine components after the crash on the machine. Replacement of engine components on corrective maintenance causes the machine to stop operating during the production process is in progress. The result is in the loss of production time due to the operator must replace the damaged engine components. The loss of production time can impact on the production targets which were not reached and lead to high loss costs. The cost for all components is Rp. 4.088.514.505. This cost is really high just for maintaining a Mill Roll Machine. Therefore PT. XYZ is needed to do preventive maintenance i.e. scheduling engine components and improving maintenance efficiency. The used methods are Reliability Engineering and Maintenance Value Stream Mapping (MVSM). The needed data in this research are the interval of time damage to engine components, opportunity cost, labor cost, component cost, corrective repair time, preventive repair time, Mean Time To Opportunity (MTTO), Mean Time To Repair (MTTR), and Mean Time To Yield (MTTY). In this research, the critical components of Mill Roll machine are Spier, Bushing, Bearing, Coupling and Roll. Determination of damage distribution, reliability, MTTF, cost of failure, cost of preventive, current state map, and future state map are done so that the replacement time for each critical component with the lowest maintenance cost and preparation of Standard Operation Procedure (SOP) are developed. For the critical component that has been determined, the Spier component replacement time interval is 228 days with a reliability value of 0,503171, Bushing component is 240 days with reliability value of 0.36861, Bearing component is 202 days with reliability value of 0,503058, Coupling component is 247 days with reliability value of 0,50108 and Roll component is 301 days with reliability value of 0,373525. The results show that the cost decreases from Rp 300,688,114 to Rp 244,384,371 obtained from corrective maintenance to preventive maintenance. While maintenance efficiency increases with the application of preventive maintenance i.e. for Spier component from 54,0540541% to 74,07407%, Bushing component from 52,3809524% to 68,75%, Bearing component from 40% to 52,63158%, Coupling component from 60.9756098% to 71.42857%, and Roll components from 64.516129% to 74.7663551%.

1. Introduction

The increasing competition in manufacturing, the company must make continuous improvement to keep the company's stability in achieving its vision.According to remain competitiveness, manufacturing companies are forced to optimize their production in terms of cost efficiency, lead time and quality [1].

One of the factors that need to be considered is the machine maintenance system. PT. XYZ is a private company engaged in the production of rubber processing into crumb rubber. The production section is supported by some interacting machines and equipment to achieve optimal productivity. The types of machines used in the production process are Conveyor Breaker, Breaker, Twin Roll, Hammer Mill, Conveyor Claw, Roll Mill, Crumb Shredder, and Dryer. To take care of the whole machine in the production, PT. XYZ implement maintenance/maintenance system. System maintenance at PT. XYZ is still corrective maintenance that is doing repair or replacement of machine components after damage to the machine. Production machines in PT. XYZ have many damaged where the frequency of breakdown and downtime of production machine exceeds the standard downtime set by the company.

The high downtime is due to the company applying corrective maintenance. If this maintenance strategy is used as the primary maintenance strategy will result in the high impact of unplanned maintenance activities from replacement parts. Replacement of components on the machine cause the engine to stop operating at the time of production process is in progress. The result is in the loss of production process time due to having to replace the damaged machine components. This is a problem at PT. XYZ due to production activities that do not run smoothly resulting in loss of production time that causes the company to experience loss production. The loss of production process time has an impact on not reaching the target on the set schedule so that causing an order delay. Loss of production time also affects the cost of loss of production during component replacement.

Based on the problem, the company suffered a lot of losses because the maintenance system used is still corrective maintenance. Therefore, it is important to apply preventive maintenance scheduled maintenance planning to perform component replacement so that the machine can operate at standard working hours without any damage during production process so that the production process can run smoothly, the target is reached on the specified schedule, and reduce the loss production time [3]. The goal of this research is to design preventive maintenance machine system with Reliability Engineering and Maintenance Value Stream Mapping (MVSM). The novelty of this research is there will be a calendar that has been marked in accordance with the replacement schedule of machine components.

Preventive maintenance is not a new method, but this method is very effective to reduce downtime and breakdown machine in a company.Previous research had been done in PT. Chaeron Phokphand Indonesia. Maintenance systems that are still breakdown maintenance and corrective maintenance cause the loss is the cost of loss of production, higher repair costs and overtime costs due to loss of production. Therefore, the calculation of machine maintenance costs on machine components, namely preventive cost (cost prevention) and failure cost (damage cost) [2]. Another research has been done in PT. XXX. The observed factory maintenance system is still corrective maintenance. This research was conducted to plan the maintenance of production machines using Reliability Engineering and MVSM (Maintenance Value Stream Mapping) method [3].

One of definition of system reliability is the ability of the system performing its intended function by using probabilistic expressions, like as the probability that the system will fail in a specified time, the expected period of time to failure and the expected number of failures for a certain period [3].

It must be known that reliability analysis is conducted and then the results are presented and also communicated to the management [4].

System Reliability analysis has objectives that all the estimating process of the system’s probability will be able to indicate its function. Reliability of system’s part influenced by the main of system reliability [5]

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2. Research Methods

The type of this research is descriptive research, that is research which aim to describe systematically, factually and accurately about facts and properties of a certain object or population. The result of this research is to give the proposal of replacement schedule of the machine component and cost calculation to minimize company expenditure especially maintenance part.

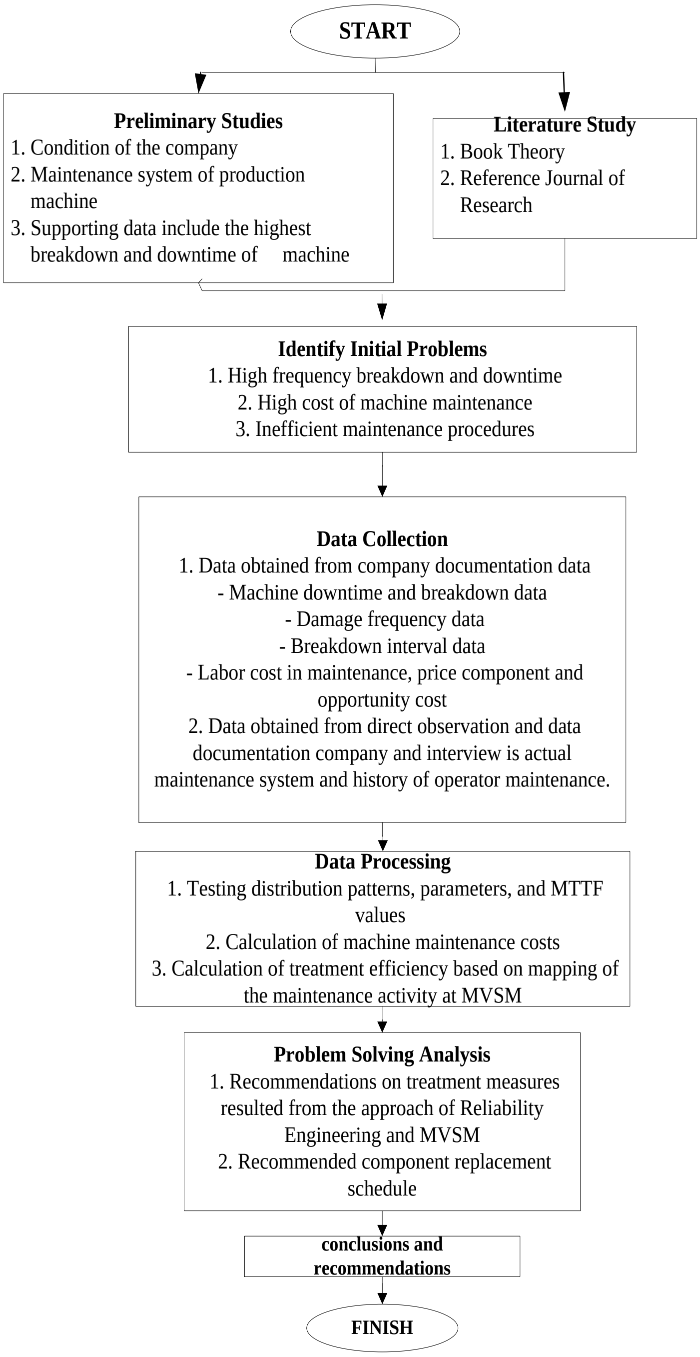

Figure 1. Reliability Engineering and Maintenance Value Stream Mapping Steps

The observed object is Mill Roll machine because this machine has the highest frequency of damage. The method begins with data collection, i.e. data collected from company documentation (machine downtime and breakdown, the frequency of damage, interval damage, maintenance personnel cost, component price, and opportunity cost), and 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 MTTF values, calculation of machine maintenance cost, and calculation of maintenance efficiency at MVSM.

VSM contains all activates that non value added as well as value added. The main objective of VSM is to select different types of wastes and then to eliminate them. The step begin with selecting a specific product as the target for improvement. The second step is developing a current state map that is mainly figure how processes are currently being done. The third step is drawing the future state map that is display of how the production process should be done after the wastes and inefficiencies have been removed. The future state map done by creating the answerof a collection of questions on topics relevant to efficiency.The last step, the suggested map is applied as a process for making essential changes to the system [6].Value Stream Mapping (VSM) method is very simple and effective to draw and redesign of value streams. So the current value stream is captured, and then value stream designed, in which sources of waste within the production process are reducedand uncovered [1].As a tool VSM help us to understand material's flow and product's information through the value stream. By calculating the difference between the current and the future state , the performance of the system could be improved [7]. The flowchart of Reliability Engineering and Maintenance Value Stream Mapping steps can be seen in Figure 1.

3. Results and Discussion

3.1. Testing Distribution

The first step in the Reliability Engineering Method is testing the distribution of each critical engine component. The results of the selected distribution pattern test for each machine component can be seen in Table 1. The preferred distribution pattern is the distribution that gets the largest Index of Fit (Correlation Coefficient) value.

Table 1. Recapitulation of Distribution Pattern of Damage Components

No.	Component	Distribution
1	*Bearing*	Normal
2	*Bushing*	*Weibull*
3	*Coupling*	Normal
4	*Spier*	Normal
5	*Roll*	*Weibull*

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 recapitulation of MTTF calculation, hence got the interval of change of each component can be seen in Table 2.

Table 2. Recapitulation of MTTF Value

No.	Component	**MTTF**
1	*Bearing*	202
2	*Bushing*	240
3	*Coupling*	247
4	*Spier*	228
5	*Roll*	301

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. Reliability calculation can be seen in Table 3.

Table 3. Reliability Calculation on Component Replacement Interval Schedule

No.	Component	Reliability
1	*Bearing*	0,503058
2	*Bushing*	0,36861
3	*Coupling*	0,50108
4	*Spier*	0,503171
5	*Roll*	0,373525

3.4. Maintenance Cost Calculation

Maintenance cost calculation is divided into two, namely cost of failure and cost of preventive. Comparison of maintenance cost of machine component can be seen in Table 4.

Table 4. Total Comparison of Maintenance Costs

No.	Component	**Cf**	**Cp**
1	*Bearing*	53.541.257	39.641.114
2	*Bushing*	59.889.400	45.988.543
3	*Coupling*	38.565.714	30.225.229
4	*Spier*	58.299.771	49.957.000
5	*Roll*	90.391.971	78.572.486
	Total	**300.688.114**	**244.384.371**

From the result of correlation ratio computation cost and preventive maintenance cost, it can be seen that there is cost saving from IDR 300,688,114 to IDR 244.384.371.

3.5. Calculation of treatment efficiency on MVSM

The first step taken on MVSM is the establishment of current state map and future state map. The comparison between current state map and future state map can be seen in Table 5.

Table 5. Comparison of Current and Future State

Component	Category	Cf	Cp
Spier	MTTO	1,5	0,5
	MTTR	2	2
	MTTY	0,2	0,2
	% Maintenance Efficiency	54,054	74,074
Bushing	MTTO	1,8	0,8
	MTTR	2,2	2,2
	MTTY	0,2	0,2
	% Maintenance Efficiency	52,380	68,75
Bearing	MTTO	1,3	0,7
	MTTR	1	1
	MTTY	0,2	0,2
	% Maintenance Efficiency	40	52,6315

Coupling	MTTO	1,5	0,9
	MTTR	2,5	2,5
	MTTY	0,1	0,1
	% Maintenance Efficiency	60,9756	71,4285
Roll	MTTO	1,9	1,05
	MTTR	4	4
	MTTY	0,3	0,3
	% Maintenance Efficiency	64,5161	74,7663

Mill Roll Machine has the greatest frequency of damage and is chosen to be a critical machine. Mill Roll is used to grind the rubber from the form of small chunks into sheets. This machine is often damaged due to several things including the incorrect installation of machine components by the operator and wear caused by two surfaces that rub against the machine at the time of operation. Machine maintenance schedule with the critical component replacement for Spier component is 228 days with reliability 0,503171, Bushing component is 240 days with reliability 0,36861, Bearing component is 202 days with reliability 0,503058, Coupling component is 247 days with reliability 0, 50108, and the Roll component is 301 days with reliability 0.373525. The machine maintenance schedule can be seen in Figures 2 and 3.

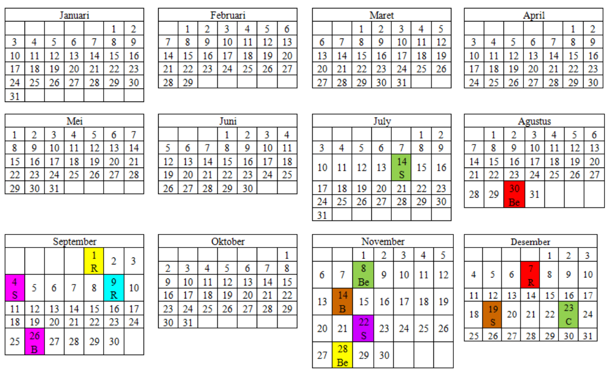

Figure 2. Schedule of Milling Machine Component Assistance Year 2016

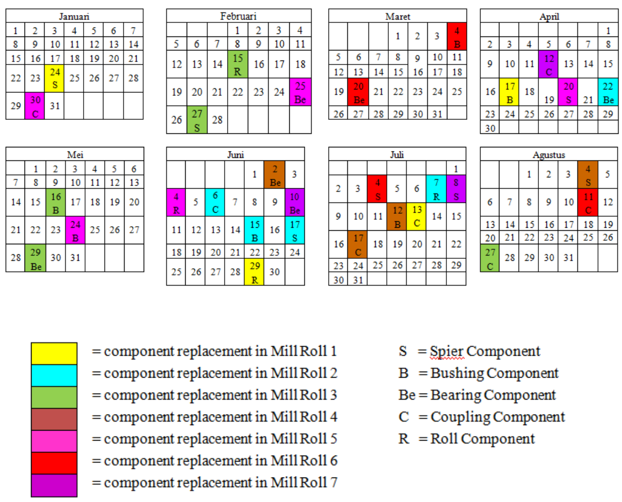

Figure 3. Schedule of Milling Machine Component Assembly Year 2017 and Description

The comparison of current machine maintenance costs and estimated cost proposals resulted in cost savings of Rp. 300,688,114 (cost of failure) to Rp. 244.384.371 (cost of preventive). While maintenance efficiency increased with preventive maintenance application that is for spier component is 74,07407% from 54,0540541%, bushing component is 68,75% from 52,380,9524%, bearing component is 52,63158% from 40%, coupling component is 71.42857% from 60.9756098%, and the Roll component is 74.7663551% of 64.516129%. Implementation of preventive maintenance is more profitable and cost-effective compared to the application of corrective maintenanceprocedure of the production area, conducting ongoing inspection in the use of PPE, and creating a slogan -Slogan 5 Keep in mind that the implementation of preventive maintenance will not be expected to prevent damage to the machine but only decrease the number of defective machines.

4. Conclusion

The critical engine that is the priority of the research is Mill Roll machine is the machine with the greatest damage frequency with critical engine components namely spier, bushing, bearing, coupling, and roll.The machine maintenance schedule with replacement of critical components for Spier component is 228 days, Bushing component is 240 days, Bearing component is 202 days, Coupling component is 247 days, and Roll component is 301 days. The reliability value of machine component on spier component replacement schedule is 0,503171, Bushing component equal to 0,36861, Bearing component equal to 0,503058, Coupling component equal to 0, 50108, and Roll component is 0.373525. The comparison of current machine maintenance costs and estimated cost proposals resulted in cost savings of Rp. 300,688,114 (cost of failure) to Rp. 244.384.371 (cost of preventive). Implementation of preventive maintenance is more profitable and cost-effective compared to the application of corrective maintenance. The results of the Stansard Operation Procedure (SOP) development with Maintenance Value Stream Mapping (MVSM) resulted in the percentage of maintenance efficiency for each component 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 the future state map for the spier component is 74.07407%, the bushing component is 68.75%, the bearing component is 52.63158%, the coupling component is 71.42857%, and the Roll component is 74.7663551%.

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