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Maintenance Strategy Improvement Design in Cigarette Paper Machine Station

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Abstract- **Maintenance is a function that monitors and maintains factory facilities, equipment and work facilities by designing, managing, handling and inspecting work to ensure the functioning of the unit during uptime and minimizing downtime caused by damage or damage. Repair. This company produces cigarette paper products in the form of bobbin (small roll) and ream (sheet of A3 paper). Preliminary observation results indicate that the high failure of machine function causes the machine efficiency is low. Machine efficiency has a considerable effect on company productivity. The low efficiency of the machine resulted in the company can not more freely expand the market and customer orders in a high quantity. In this case, an effort to improve the efficiency of paper machine using Reliability Centered Maintenance method. FMEA analysis results show that bearing bush, antifriction bearing, carbon guide, press capter and lock washer are the components that have the highest priority level. The maintenance actions that a company can undertake based on this research are to tailor care measures to the category of critical components. Components with the Condition Directed category are treated through cleaning and inspection. The Time Directed category is treated by replacing and repairing components in accordance with the calculated schedule through distribution testing approach and Mean Time To Failure (MTTF). The result of RCM calculation shows there is difference of average value of reliability before and after RCM application that is 0,5134 with 0,9316. This increase in reliability values leads to a decrease in the value of downtime proven by increasing the availability of critical components.**

Keywords: Maintenance Strategy, Mean Time To Failure (MTTF), Reliability Centered Maintenance.

I. INTRODUCTION

The reliability of industrial machines is the center of attention for companies to be able to meet the quality and quantity of products required by customers. The reliability level of a machine can be seen from the low frequency of machine failure function, where if the frequency of machine failure is low then the machine reliability will be higher. The decline in machine reliability has a huge impact on machine efficiency and has a poor impact on its ability to provide accurate short-term forecasting for machine operating hours.

Failure of machine function has a broad loss effect on the company, in addition to the loss of not reaching the amount of production, the company also suffered losses in the form of increased production costs, labor costs, the cost of processing defective product recycling due to damaged machine, wasted energy costs in vain, and etc. This increase in cost will affect the increase in the price of products to be sold to customers. In other words, the failure of machine function is one of the causes of the increase of product selling price.

According to [1], for continious process production process, the recommended treatment system is using Reliability Centered Manintenance (RCM) compared to Total Productive Maintenance (TPM) or Bussiness Centered Maintennace (BCM) method. [2] states that the RCM method focuses on the functioning of the system and directs maintenance efforts in parts and units where critical reliability.

The object of this research is a company produces cigarette paper products in the form of bobbin (small roll) and ream (sheet of A3 paper). The product generated by 40% is sent to PT. Sempoerna and the rest of the tobacco companies located in Sumatra and Java. The company has 1 (one) machine which is paper machine that operates for 24 hours continuously and is an old machine that operated. Due to the production process at this company is continious process and this research is focused on system function in reducing downtime, hence researcher use RCM method to do repair maintenance system.

II. LITERATURE REVIEW

The machines and equipment used by companies today are usually complex and require substantial capital investment. It is hard to imagine when equipment and machines are not maintained. However, very surprisingly in this twenty-first century, there are still many companies that do not seem to realize the potential benefits that await them. They may never consider remedial techniques unless they find equipment problems, at which point they will seek professional help and government organizations, for example, the Manufacturing Institute, the Department of Commerce and Industry [3]. Maintenance is a function that monitors and maintains factory facilities, equipment and work facilities by designing, managing, handling and inspecting work to ensure the functioning of the unit during uptime and minimizing the downtime caused by the damage.

A. Maintenance Strategy

According to [4] there are three strategies in machine or equipment maintenance: preventive repair, Corrective repair (day to day) and condition based maintenance.

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The maintenance manager may decide to conduct routine checks or simply perform maintenance after a functional failure of the equipment or machine occurs. However it would be better if all the treatment actions are well done to anticipate the failure of the element or correct the logical defects.

a. Corrective Maintenance

Corrective maintenance is an unplanned maintenance strategy, which means maintenance is done after a failure is found. In this case the meaning of corrective is a maintenance action performed in reaction to the failure of the function that occurs. So, the maintenance is in the form of repair or repair of machinery and equipment is done only if the machine or equipment is damaged.

b. Condition Based Maintenance (CBM)

Condition Based Maintenance (CBM) is a maintenance strategy that applies visual inspection or through measurement of machine and equipment condition. Treatment actions will be taken if equipment or machinery conditions deteriorate. This is considered to be more cost-effective than previous treatments. Because, treatment actions will be done when the machine condition will deteriorate and the time required depends on the condition of equipment on the production floor. However, this treatment strategy is not yet optimal enough to prevent equipment damage and keep the general economical of equipment longer.

c. Preventive Maintenance

Preventive maintenance is a planned maintenance also known as forward care and involves forecasting of maintenance needs. In preventive maintenance, work is scheduled according to the time specified. Preventive can be used to predict a failure and during which period the equipment will fail. This is a care that can be done when the goods are in service. This is a concept that may be more appropriate for equipment that often suffers wear and tear. Wordsworth suggests that planned preventive maintenance is useful if the cost is more efficient, meaning to meet the client's needs from an operational point of view, reducing maintenance incidents requiring repeated requests, there is a dominant work occurrence for the craftsman than the inspection. In the planned preventive maintenance, planning and implementation of maintenance work is done to anticipate the failure of the facility [4].

B. Reliability Centered Maintenance

Reliability Centered Maintenance (RCM) is a logical engineering process for determining maintenance tasks that will ensure a reliability system design with specific operating conditions in a particular operating environment. In other words Reliability Centred Maintenance (RCM) can be defined a process used to determine what should be done to ensure that each physical asset continues to do whatever the user wants to do in the context of the operation [5].

According to [6] in the RCM process required 7 (seven) questions about the assets or system in conducting the review, as for the question is as follows:

1. What is the expected function and standard of performance of the asset in its operation (function)?
2. In what form can the asset not fulfill its function (malfunction)?
3. What causes failure (failure mode)?
4. What happens during a failure (failure effect)?
5. What are the consequences of each failure (consequence of failure)?
6. What should be done to forecast or prevent failure (preventive and interval actions)?
7. What should be done if no suitable preventive measures are found (standard actions)?

RCM program in general is a program used by the industry / factory to maintain the reliability of equipment / facilities in accordance with standard performanceperalatan / facilities in it. A good and effective preventive maintenance (PM) program will be able to create reliability according to performance standards. According to [7] RCM program has three phases / stages, namely:

1. The stage consists of identifying equipment essential for plant safety, power generation (or production), and asset protection.
2. The stage consisting of determining the tasks required of PM for the equipment is identified in phase 1. These tasks must go well and effectively.
3. The stage consisting of the execution of the task specified in phase 2 correctly.

The reliability function [8] is a mathematical function that shows the relationship of reliability with time. The reliability value is the probability value, and then the value of the reliability function (R) is in the range $0 \leq R \geq 1$. It is denoted as the reliability function R (t) of the m system if it is used for unit t of time. The concept of time in reliability is time to failure (TTF). Basically the calculation of reliability follows the function in accordance with the distribution of each component or machine. There are four types of distributions commonly used in the calculation of reliability functions that are weibull, normal, lognormal and exponential.

If the failure time distribution of a component, subsystem or system follows the Weibull distribution, then:

a. Equation Weibull distribution function reliability

$$R(t)= \exp\left[-\left(\frac{t-\gamma}{\alpha}\right)^{\beta}\right]$$

b. Failure Rate Weibull Distribution

$$\lambda = \frac{\beta}{\alpha}\left[\frac{t-\gamma}{\alpha}\right]^{\beta-1}$$

c. Mean Time to Failure (MTTF)

$$MTTF = \gamma + \alpha r\left(1+\frac{1}{\beta}\right)$$

If the time distribution between system failures follows a normal distribution.

a. Reliability equation of normal distribution function as follows

$$R(t) = 1 - \Phi\left(\frac{t-\mu}{\sigma}\right)$$

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b. Failure rate normal distribution

$$\lambda(t) = \frac{\exp[-(t-\mu)^2 / 2\sigma^2]}{\int_t^{\infty} \exp[-(t-\mu)^2 2\sigma^2]dt}$$

c. *Mean time to failure* (MTTF)

MTTF= μ

If the time distribution between failures follows the lognormal distribution.

a. Equality of lognormal reliability distribution function.

$$R(t) = 1 - \int_0^t \frac{1}{\sigma t\sqrt{2\pi}} \exp\left[-\frac{1}{2}\left(\frac{\ln t - \mu}{\sigma}\right)^2\right]dt$$

b. Failure rate lognormal distribution

$$\lambda(t) = \frac{f(t)}{R(t)}$$

c. *Mean time to failure* (MTTF)

$$MTTF = \exp(\mu + \frac{\sigma^2}{2})$$

If the time distribution between failures follows the eksponential distribution.

a. Equality of eksponential reliability distribution function.

$$R(t) = e^{-\lambda(t\gamma)}$$

b. Failure rate eksponensial distribution

$$\lambda(t) = \lambda$$

c. *Mean time to failure* (MTTF)

$$MTTF = \gamma + \frac{1}{\lambda}$$

III. RESULTS AND DISCUSSIONS

Based on the identification of the problem, the factor causing the downtime of cigarette paper production machine due to the failure of the component. With the high downtime, causing the efficiency of paper machine is also low. Priority levels considered to be at high risk for component damage are shown in the Risk Priority Number (RPN) value. RPN is influenced by the seriousness of the effect (severity), the probability of cause causing failure associated with the effect (occurrence), and the ability to detect failures before the detection. The value for each component that has been sorted by priority can be seen in Table 1.

Based on the FMEA results it can be seen that the most critical components with the highest priority are bearing bush, antifriction bearing, carbon guide, press capter and lock washer.

Table 1 RPN Failure Paper Machine Component

No	Parts	RPN
1	Carbon Guide	175
2	Spring	90
3	Rotary Join	75
4	Anti Friction Bearing	200
5	Bearing Bush	210
6	Mechanical Seall ID 24	80
7	Knives In Z 30 C 13	168
8	V-Belt SPC 6700	50
9	Vane Insert	90
10	Oil Seal ZF 20	24
11	Wear Ring f 120 - f 85 x 40	60
12	Press Capter	252

Based on the results of LTA analysis (logic tree analysis) components of paper machines are categorized into 4 parts, namely:

1. Category A (Safety Problem)

That is the component that can lead to work accidents on employees or operators on the production floor. The components included in this category are as follows.

A. Carbon Guide
B. Mechanical seall
C. Vane Insert

2. Category B (Outage Problem)

It is a component that can result in failure of the whole or part of the system. The components contained in this category are as follows.

A. Spring
B. Rotary join
C. Bearing Bush
D. Wear Ring f 120 - f 85 x 40
E. Ring IE 772 071 PAULSTRA
F. Joint V Ring
G. Bearing
H. Lock Nut
I. Lock Washer

3. Category C (Economic Problem)

It is a component that can result in economic losses. The components that are part of this category are as follows.

A. Knives In Z 30 C 13
B. Press capter

4. Category D (Hidden Problem)

That is a critical component that can not be detected by the operator or the employee will be the failure of its function caused because the component is not visible to the naked eye.

A. Anti Friction Bearing
B. V-Belt
C. Oil Seal ZF 20
D. Joint R 40
E. Sleeve Adapter

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Recapitulation of LTA compilation results can be seen in table 2. Based on the table obtained percentage of damage categories that are safety problems (42.11%) and B (Outage Problem).

Based on the results of the selection of actions for components of paper machines that experience kegegalan in cigarette paper production system then obtained some election actions [7], namely:

1. Condition Directed (CD) is the action taken usually analyze, monitor the condition of a component to determine whether the operation will run lancara or fail. The components included in the selection of these actions are:
   A. Carbon Guide
   B. Rotary Joint
   C. Mechanical Seall ID 24
2. Time Directed (TD) is the action taken usually includes the replacement and repair of machine components with a certain priority. The components included in the selection of these actions are:

A. Spring
B. Bearing bush
C. Knives In Z 30 C 13
D. Vane Insert
E. Wear Ring F 120
F. Press Capter
G. Ring IE 772
H. Joint V-Ring
I. Bearing No. 23034 K C3
J. Lock Nut
K. Lock Washer

3. Finding Failure (F.F) is action taken in order to find hidden equipment damage with periodic checks. The components included in the selection of these actions are:

A. Anti Friction Bearing
B. V-belt SPC 6700
C. Oil Seal ZF 20
D. Joint R 40
E. Sleeve Adapter

Based on the results of RCM approach, to improve the efficiency of the machine is scheduling the replacement of critical components so that the paper machine can work optimally. Scheduling is performed on Time Directed (TD) components, ie Spring, Bearing Bush, Knives In Z 30, Vane Insert, Wear Ring, Press Capter, IE 772 071, Joint V-Ring, Bearing, Lock Nut and Lock Washer. Determine the schedule of replacement of components first with the test distribution using software feat easy. After that calculation of reliability and MTTF (mean time to failure).

Table 2. Recapitulation of MTTF Calculation (Mean Time To Failure)

No	Component	MTTF
1	Spring	22.5699
2	*Bearing bush*	27.4063
3	*Knives In Z 30 C 13*	30.4170
4	*Vane Insert*	45.6250
5	*Wear Ring F 120*	18.2500
6	*Press Capter*	17.3823
7	*Ring IE 772*	23.8940
8	*Joint V-Ring*	28.6687
9	*Bearing No 23034 K C3*	12.1670
10	*Lock Nut*	11.8313
11	*Lock Washer*	14.4537

Reliability of each critical component affects the downtime of paper machine to produce cigarette paper. Reliability refers to the ability of the machine or component to perform its functions as expected. The comparison of reliability before and after the RCM implementation can be seen in the graph shown in Figure 1.

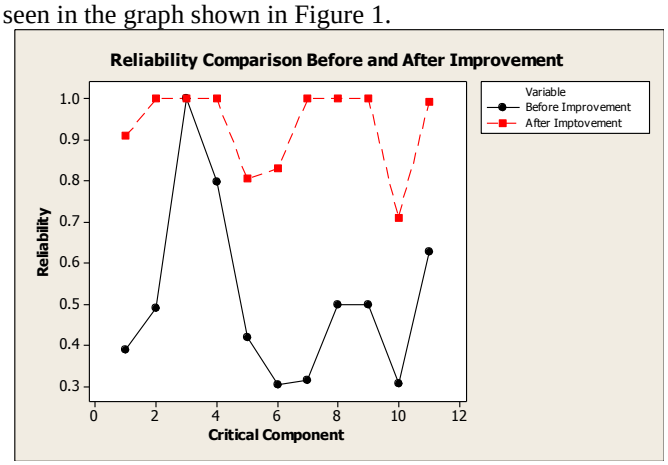

Figure 1. Reliabiliy Comparison Before and After RCM Implementation

Increased reliability of critical paper machine components from before improvement with an average reliability of 0.5134 with after improvement with an average reliability of 0.9136. This increase in reliability can cause downtime paper machine on the production floor will decrease. This can be proved by increasing the availability of each critical component. Availability refers to the availability of components or machines to operate according to their function. With the increase of reliability value, then this also result in higher component availability.

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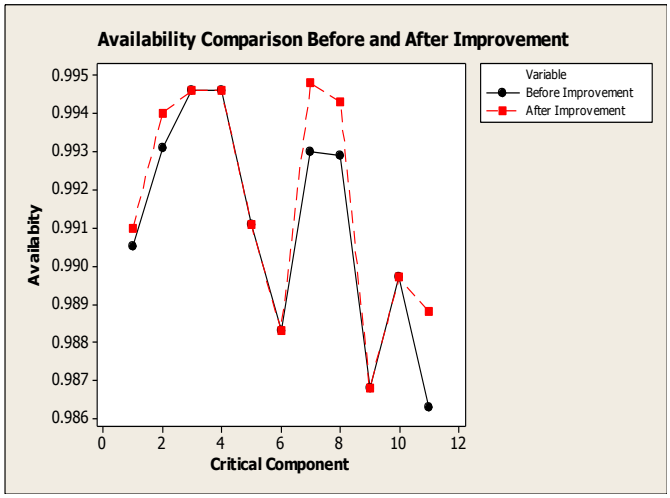

Figure 2. Increase Value of Critical Component Availability on Paper Machine

IV. CONCLUSIONS

Based on the results of data processing and discussion it can be obtained conclusion as follows.

1. Based on observations and historical data the paper machine company has 19 critical components that can reduce the efficiency of paper machines in producing cigarette paper. FMEA analysis results show that bearing bush, antifriction bearing, carbon guide, press capter and lock washer are the components that have the highest priority level.
2. Based on the MTTF calculation results obtained component replacement schedule to improve paper machine efficiency that can be applied by the company.
3. The maintenance actions that a company can undertake based on this research is to tailor care measures to the category of critical components. Components with the Condition Directed category are treated through cleaning and inspection. The Time Directed category is treated by replacing and repairing components according to the calculated schedule through the distribution testing approach and MTTF.
4. The improvement of maintenance system using reliability centered maintenance (RCM) method shows an increase in the average reliability value from 0.5134 to 0.9136 for critical component in paper machine. By increasing the value of reliability, the increased availability of components that cause downtime on the paper machine will be lower.

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