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Implementation of the Age Replacement Method for Moulding Machine Maintenance at PT. KMI

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***Abstract*— The rapid development of the industrial world has caused the manufacturing industry to think hard to survive the fierce competition. PT. KMI is a company engaged in industrial furniture, oriented to the best quality in its products and supported by sophisticated technology in the production process. The problem that occurs is unexpected machine damage, causing the production process to stop. The way to overcome this is to schedule the replacement of components that are susceptible to damage, especially sensors, bearings, and roller trans. Determination of critical components using the ABC method and the age replacement method. The selection of damage distribution, at this stage, is based on the goodness of fit value. One way to increase productivity is to schedule the replacement of components that are susceptible to damage, especially sensors, bearings, and roller trans. The recommended replacement time is 128 days for sensors with a cost reduction of IDR 1.848.097 for replacement of sensor components, 261 days for bearing components with a cost reduction of IDR 1.301.553 and 251 days for roller trans components with a cost reduction of IDR 1.646.870. by using the ABC method, 3 critical components can be found, namely sensors and bearings with a percentage value of 42.80% for sensors, 20.95% for bearings, and 14.03% for Roller trans. The most optimal time interval for the three components is the sensor component, 128 days, with downtime cost savings of IDR 1.848.097. The bearing component is 261 days with downtime cost savings of IDR 1.301.553. The roller trans component 251 days with downtime cost savings of IDR 1.646.870.**

Key Words: age replacement, bearing, component, roller, sensor

I. INTRODUCTION

The development of the global market in the industrial sector has triggered increasingly intense competition. Companies are required to carry out processes and produce high-quality products, both based on consumer and company standards. Industry acts as a source that produces and provides products or services needed by the wider community. (Srirahayu, 2021). Industries that are increasingly dependent on machines in producing goods. The machines used are physical aspects that require maintenance so that the company remains productive. Maintenance is defined as an activity carried out to it can restore or maintain the machine in optimal condition to be able to operate. (Ardiansyah & Widjajati, 2021).

(Ar-Royyan & Mukhtar, 2023) Put forward another definition of maintenance as a series of activities or actions carried out continuously with the aim of keeping the equipment in good and optimal condition.

The production process in the manufacturing industry uses machines, and the continuous use of machines to achieve production targets that sometimes exceed capacity can reduce machine performance, shorten machine life, and result in the need to replace damaged components. (Pardiyono & Suryani, 2020)

The Age replacement method is a preventive maintenance method that can estimate the replacement of components that have reached a certain age, based on damage data. (Dio et al., 2023). Virana Putra et al. (2022) Conducted a study using the age replacement method. The results obtained were that the rate of component damage increased according to increased usage, equipment that had had component replacement

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would return to its original condition, and there were no problems in component inventory.

Age Replacement is a replacement model where the component replacement time interval is carried out by taking into account the service life of the component, so that it can avoid the occurrence of equipment that has just been installed being replaced in a relatively short time (Jardine & Tsang, 2013)

(Chien et al., 2014) Conducted a study on the age replacement method with the condition that if the tool is damaged before the specified time, then the component replacement process will be carried out when the component reaches its optimal age. This is calculated from the date of component replacement, so that it can save maintenance costs.

PT. KMI has various production machines. The molding machine is one of the mandatory machines, because all production processes go through the molding machine. Therefore, special attention is needed in the maintenance of the molding machine. The type of reactive maintenance is to repair if there is damage or breakdown. (Ali M & Kusuma, 2019).

The proposed machine maintenance scheduling at PT. KMI is in the form of component replacement time and component inspection time for critical components on critical machines, so that the proposed preventive maintenance scheduling will also result in a decrease in downtime, a decrease in maintenance costs, an increase in availability, and an increase in the reliability of critical machines.

II. METHOD

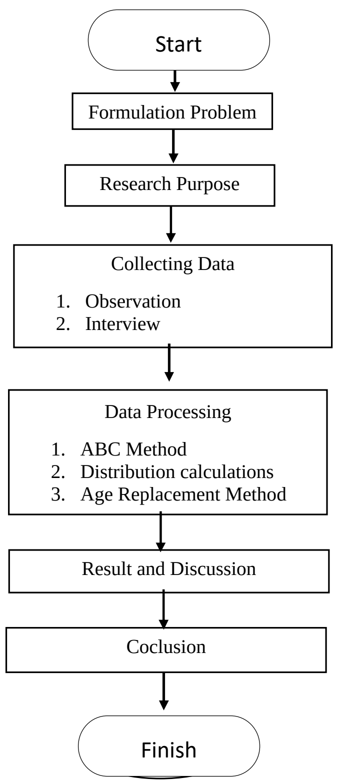

Figure 1: Research Design

a. Formulation Problem

In this discussion, the problem is formulated using the Age Replacement method.

b. Research Purpose

Benefits of the Research, for the company, for the author, for the university, and the purpose of the research, identifying damage that occurs to machine components, and determining the optimal time interval for critical molding machine components that need to be replaced.

Collecting Data

Data collection is a step to obtaining the data needed for the study.

d. Data Processing

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Carrying out the processing of what has been collected based on the theory derived from the literature study. Data processing produces the most optimal time interval for using machine components, optimal annual maintenance on the machine, and minimizing costs for machine maintenance.

e. Results and Discussion

This stage contains a discussion using the Age Replacement method.

f. Conclusions

Conclusions are made to find out the results of the research that has been carried out, in order to find out whether a study is successful or not. After making a conclusion, the next step is to determine suggestions in the form of input to the company and subsequent researchers.

The research variables studied are Downtime Damage to Molding Machine, Maintenance Time on Each Machine Component, Cost of Loss During Downtime, Machine Maintenance Cost, Machine Maintenance Cost.

Data Analysis Methods

According to (Praharsi et al., 2015), 2015 the steps in calculating the Age Replacement method are as follows:

1. Determine critical components of critical machines based on machine failure data, using the Pereto diagram to determine critical components.
2. Performing calculations and analysis of component damage data, by calculating the Time to failure (TTF) and Time to repair (TTR) of critical components. TTF calculations are performed by calculating the time difference between the first damage is completed and the time of the next damage and TTR calculations are performed by calculating the length of the repair process, namely the time difference when the damage is completed and the time of damage.
3. Calculating the Index of fit, parameter estimation, goodness of fit, MTTF, and MTTR values.

$$M = \alpha \left(1 \frac{1}{p}\right) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

Where:
α = Scale parameter (alpha)
β = Shape parameter (beta)
Γ = Gamma function

$$M = \frac{A \quad a \; R \quad Ti}{A \quad a \; R} \ldots\ldots\ldots\ldots\ldots\ldots(2)$$

4. Calculating the intervals for preventive maintenance and component inspection.
5. Calculate the replacement interval of components that must be replaced if damaged.

Inspection intervals and availability levels.

The calculation formula for the Age Replacement method is as follows (Muzakki, 2021)

$$D(t) = \frac{T \quad (t\ ) + T\ (1 - R(t\ ))}{(t + T\ )R(t\ ) + \left(M(t\ )\right] + T\ (1 - R(t\ ))} \ldots\ldots\ldots\ldots\ldots(3)$$

Where:
D(tp) = total downtime per unit time for preventive replacement
tp = length of cycle (time interval) preventive
Tp = downtime due to preventive action
Tf = downtime due to component failure
M(tp) = expected value of the failure cycle length

III. Results and Discussion

After collecting data, the next step is to determine the critical components using the ABC method, which is carried out on the molding machine as in Table 1:

Table 1 Critical Component Data

Component	Amount	Price/Unit (IDR)	Breakdown Frequency	Total Cost (IDR)
Inventers	1	1.520.000	2	3.000.000
GearBox	6	525.000	5	15.750.000
Bering	16	350.000	6	33.600.000
AS	6	935.000	3	16.830.000
Roller Trans	5	750.000	6	22.500.000
Sensors	22	390.000	8	68.640.000

After that, calculate the percentage cost of each component and sort it from the largest to the smallest amount, then the components are classified using the ABC method as in Table 2:

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Table 2: ABC Method

No	Component	Percentage Frequency	Category
1	Sensors	42.80%	A
2	Bering	63.75%	
3	Roller Trans	77.78%	
4	AS	88.28%	B
5	GearBox	98.1%	
6	Inventers	100%	C

The goodness of fit test is conducted to determine the type of distribution of TTR and TTF data and to determine the MTTR and MTTF values of each component. Table 3 shows the results of the TTR repair time distribution test, while Table 4 shows the results of the TTF damage time distribution test.

Table 3 Goodness Of Fit TTR

Component	Distribution	Scale	Shape
Sensors	Weibull	6.05864	1236.86
Bering	Weibull	3.95032	3.95032
Roller Trans	Weibull	3.46938	155.094

Table 4 MTTR Result

Component	Distribution	α	β	MTTR
Sensors	Weibull	6.05864	1236.86	110.69
Bering	Weibull	3.95032	3.95032	41.521
Roller Trans	Weibull	3.46398	155.094	139.46

The Mean Time to Failure calculation requires parameters from the selected distribution calculation. Therefore, to calculate MTTF, each component is different. Table 5 is a table of parameters and MTTF results for each component.

Table 5: MTTF Result

Component	Distribution	Scale	Shape	MTTF
Sensors	Weibull	6.05864	1236.86	1148
Bering	Weibull	3.95032	3.95032	1603
Roller Trans	Weibull	1161.51	4.14963	1055

From the calculation results, the MTTF value is then calculated to determine the reliability value of each component. The calculation results can be seen in Table 6 as follows.

Table 6 Reliability

Component	Distribution	MTTF	R9t)
Sensors	Weibull	1148	0.529151315
Bering	Weibull	1603	0.509078758
Roller Trans	Weibull	1053	0.51092252

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The next step is to calculate the maintenance costs and component damage. The results of this calculation are to find the optimal time for the maintenance interval that should be carried out. Maintenance costs are costs that arise due to maintenance. Maintenance costs include labor costs, downtime costs, and spare part costs. Maintenance costs for each component can be seen in Table 7 as follows.

Table 7: Maintenance Costs

Component	Price (IDR)	MTTR (Hours)	Labour Cost (IDR)	CM (IDR)
Sensors	390.000	107.698	37.500	4.425.000
Bering	350.000	126.87	37.500	5.105.000
Roller Trans	750.000	139.46	37.500	5.979.750

The results of the calculation of repair costs due to component damage for each maintenance cycle are shown in Table 8 as follows.

Table 8: Repair Costs

Component	Price (IDR)	MTTR (Hours)	Labour Cost (IDR)	Loss Costs(IDR)	CF (IDR)
Sensors	390.000	107.698	37.500	20.000.000	215.237.500
Bering	350.000	126.87	37.500	20.000.000	253.637.500
Roller Trans	750.000	139.46	37.500	20.000.000	278.957.500

Next is to calculate using the Age replacement method to find out the results of reducing repair costs. The calculation results of the Age replacement method can be seen in Table 9 below.

Table 9: Age Replacement Method

Component	tp	R(tp)	M(tp)	D(tp) (IDR)
Sensors	128	0.529151315	2.438312	1.848.097
Bering	261	0.509078758	3266.812	1.301.553
Roller Trans	251	0.51092252	2157.139	1.646.870

Unexpected machine failures often occur, causing the production process to stop. One way to increase productivity is to schedule replacement of components that are prone to damage, especially sensors, bearings, and roller trans. The recommended replacement time is 128 days for sensors with a cost reduction of IDR 1.848.097 for replacement of sensor components, 261 days for bearing components with a cost reduction of IDR.1.301.553, and 251 days for roller trans components with a cost reduction of IDR 1.646.870.

IV. CONCLUSION

By using the ABC method, 3 critical components can be found, namely sensors and bearings with a percentage value of 42.80% for sensors, 20.95% for bearings, and 14.03% for Roller trans. The ABC method has proven effective in identifying key components that require more attention to optimizing maintenance strategies. The implementation of this method provides an efficient solution that can significantly reduce downtime costs while ensuring system performance remains stable and reliable.

The application of the Age Replacement method has successfully determined the optimal

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maintenance interval for three critical components, namely sensors, bearings, and roller trans, as follows:

a. Sensor: A replacement interval of every 128 days provides downtime cost savings of Rp1,848,097, with a contribution of 42.80% of the total damage cost.

b. Bearing: A replacement interval of every 261 days provides downtime cost savings of Rp1,301,553, with a contribution of 20.95% of the total damage cost.

c. Roller trans: A replacement interval of every 251 days provides downtime cost savings of Rp1,646,870, with a contribution of 14.03% of the total damage cost.

This Age Replacement approach has proven its effectiveness in significantly reducing downtime costs by determining the optimal component replacement schedule. Implementing this strategy not only increases cost efficiency but also extends the overall system life.

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