Predictive Maintenance Analysis Overhead Crane Machine in PT Bromo Steel Indonesia

by Dimas Indra Laksmana

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Predictive Maintenance Analysis Overhead Crane Machine in PT Bromo Steel Indonesia

Sofian Hadi, Dayal Gustopo and Dimas Indra

Departemen of Industrial Engineering, National of Technology Institute Malang, Malang 65152, Indonesia

Sofianhadie67@gmail.com

Abstract. Problems that often occur in the production process at PT. Bromo Steel Indonesia is damage to the engine overhead crane. The damage that occurs to the engine, has a negative impact on the company, where the production process stops. The purpose of this research is to design maintenance schedules, reduce engine overhead crane downtime, improve Standard Operating Procedures. Based on the results of the research, maintenance intervals on overhead crane engine components are brake systems for 95 days, carbon brush for 27 days, electric hoist for 46 days, limit device for 47 days, clutch for 56 days, pull motor for 31 days, drum roll electric for 44 days, wire rope for 29 days. Changes to the maintenance system from breakdown maintenance to predictive maintenance resulted in saving cost of 27,62% on overhead crane machines component with a nominal value of IDR 1.051.031.511 and result of the analysis of the calculation overall equipment effectiveness at PT Bromo Steel Indonesia before predictive maintenance of 90,19% and after predictive maintenance of 92,06% an increase 1,87 %.

1. Introduction

Along with the advancement of science and technology in the field of industry, the company will strive to continue to develop to achieve the targets, targets or objectives that have been determined. One of the factors supporting success in achieving company goals is the maintenance of machinery and equipment. PT. Bromo Steel Indonesia is a manufacturing company (General Contractor) that is engaged in the manufacture of pressure vessels, steel structures, agro-industries and others. Market demand is increasing from year to year, both from regional and international regions, encouraging companies to increase productivity in the production process. If the machine has trouble, it will affect the production performance so that a machine that has availability and reliability is needed to achieve the target [1]. Availability is the capability of repairs that will restore the system to operating conditions, an alternative measure of system performance [2]. Maintenance is an activity to maintain or maintain facilities and equipment factories and replacements needed so that there is a satisfactory operating situation as planned [3]. With the disruption of the production process over time, the production time capacity of PT Bromo Steel Indonesia at idle hours and greater absences resulted in decreased performance and efficiency of the company. We can see downtime in table I below:

Table 1. Downtime in PT. Bromo Steel Indonesia

Overhead crane component	Frequency	Downtime (Hours)	Time To Repair (Hours)	Failure Cost (IDR)
Contactor	48	63,57	1,326	10.167.585
Hoist Crane	51	116,08	2,276	54.111.006
Wheel & Railway	18	48,82	2,712	25.001.205
Insulated Bridge	15	16,78	1,219	19.914.778
Total	132	245,35	7,533	109.194.575

In this study aims to design predictive maintenance scheduling based on analysis of availability, reliability and optimal maintenance time intervals. Predictive Maintenance is a timely treatment strategy or Just In Time [4]. Predictive maintenance can be described as a process that requires technology and people's skills and combines all diagnostic data and available performance, maintenance history, operator logs, and design data to make timely decisions about critical component maintenance requirements [5]. Predictive Maintenance (PdM) is a form of maintenance that directly monitors the condition and performance of the engine during normal operations to reduce damage or failures in the future. The objectives in this study are as follows: Design scheduling of critical component replacement maintenance for overhead crane machines with Total Minimum Downtime criteria, reduce critical component downtime for engine overhead cranes, improve Standard Operating Procedure Maintenance system of PT. Bromo Steel Indonesia.

2. Research Methodology

2.1 Maintenance Interval Based on Total Minimum Downtime

Determination of optimum preventive actions by minimizing downtime will be stated based on replacement time intervals. The method used to minimize downtime is age replacement. Before damage occurs due to the age limit of use of these components will still be replaced, and if there is damage before the age of use of these components will also remain replaced. In the interval (tp) chosen is when D (tp) has a minimum value as below:

$$D\ (tp) = \frac{tp.R(tp)+(1.R(tp)).Tf}{(tp+Tp).R(tp)+(M\ (tp)+Tf)(1-R(tp))} \quad (1)$$

2.2 System Scheduling Using to Age Replacemnet Method

Preventive care methods in this study used the age replacement method. This method is a maintenance method that is determined by a time interval of prevention based on the time interval of failure or damage due to repair of component replacements according to the minimization criteria [6].

2.3 Efficiency Process

To find out the indicators of the effectiveness of the resources they have (the level of reliability, the level of productivity, etc.) the use of machines or equipment used, it is necessary to approach the Overall Equipment Effectiveness (OEE) [7]. OEE itself is obtained from the calculation of the availability of equipment, the work efficiency of a production process, and the ratio of product quality. Implementation in the application of the Overall Equipment Effectiveness (OEE) method by calculating the OEE component, namely:

1. Availability Ratio

   Is a ratio that describes the use of the time available for the operation of machinery or equipment. In other words, the formula used is:

$$Availability\ Rate = \frac{Operating\ time}{loading\ time}\ x\ 100\ \% \quad (2)$$

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2. Performance Efficiency
   Is a ratio or comparison that describes the ability of the equipment to produce goods or products expressed in percentages. Then the formula used by Performance Efficiency is
   $$Performance\ eficiency = \frac{amount\ of\ production}{ideal\ cycle\ x\ operating\ time}\ x\ 100\ \% \quad (3)$$
3. Rate Of Quality Product
   A ratio describes the ability of equipment to produce products that are in accordance with standards. Or you could say comparison of the number of products that are good for the number of products processed.
   $$Rate\ of\ Quality\ Product = \frac{value\ operation\ time}{producted}\ x\ 100\ \% \quad (4)$$

3. Discussion

3.1. Critical Component Selections

Determination of critical components based on several factors: high total maintenance costs, large downtime, loss of production costs, frequency of damage or replacement very often, and the high cost of components. Regarding downtime data or damage to machine components due to several factors, it will be described in detail in table II according to the following:

Table 2. Critical Component Selection to Overhead Crane

Component Type	Frequency	Component Price (IDR)	Total Componen Price (IDR)
Brake System	2	975.000	1.950.000
Carbon Brush	12	750.000	9.000.000
Electric Hoist	7	28.000.000	196.000.000
Clutch	3	1.300.000	3.900.000
Limit Device	3	676.000	2.028.000
Stator	10	1.750.000	17.500.000

3.2. Testing Damage and Parameter Distribution Pattern

The frequency of damage to components that will be tested for normality using the goodness of fit test using the Minitab software 18. The test of goodness of fit test is done to determine the compatibility or compatibility between the reliability of the data with engine failure, namely by distributing the right plot. Where the plot can evaluate each variable, function reliability and hazard function. One of the results of testing the distribution pattern can be seen in Figure 1 as below:

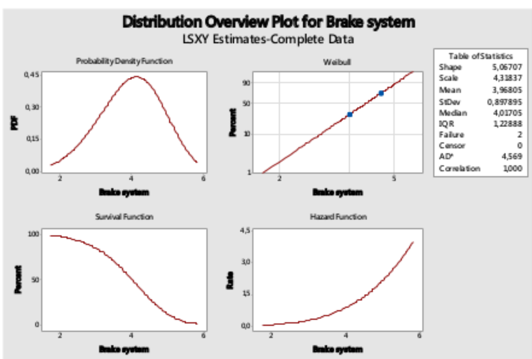

Figure 1. Distribution Overview Plot (File Processing)

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3.3. Component Interval With Total Minimum Downtime Criteria

At this writing, an approach using Minimum Total Downtime is used to minimize the period of damage in making critical component replacement decisions. The time to replace components due to damage can be symbolized by Tf which is obtained from the calculation value of Mean Time To Repair (MTTR) on critical components as well as preventive component replacement time can be symbolized as Tp. The Tf and Tp values of each critical component can be seen in table 3 below:

Table 3 Replacement of Duration Components and Table 4 Maintenance interval:

Table 3. Replacement of Duration Components

Component Type	Patter Distribution	Parameter		Replacement Duration	
		Scale (α)	Shape (β)	MTTR /Tf (Hours)	Tp (Hours)
Brake System	Weibull	4,318	5,06	4,3183	5,0670
Carbon Brush	Weibull	2,104	1,30	2,1046	1,3023
Electric Hoist	Weibull	3,686	1,81	3,6866	1,8190
Clutch	Weibull	2,311	2,01	2,3119	2,0187
Limit Device	Weibull	1,660	1,56	1,6607	1,5688
Stator	Weibull	2,279	1,46	2,2791	1,4633

Table 4. Maintenance Intervals with the Total Minimum Downtime concept

Component Type	Frequency	F (t)	H (tp)	D (t)	A_i
Brake System	2	0,0200	0,02004	0,359	0,995797
Carbon Brush	12	0,9999	9,88636	1,555	0,987734
Electric Hoist	7	0,9596	3,37226	1,506	0,987938
Clutch	3	0,8158	1,31705	0,924	0,996739
Limit Device	3	0,9202	1,84572	0,938	0,997623
Stator	10	0,9998	7,84685	1,562	0,98914

3.4. Scheduling Maintenance with Age Replacement Method

Scheduling machine maintenance using the age replacement method is a prevention method before experiencing failure of engine functions by setting a maintenance time interval based on the interval of failure with the replacement component with minimization criteria. And for other components obtained in the same way as the results in table 5 below:

Table 5. Schedule Maintenance

Component Type	(1/µ)	Examination Average (1/i)	Interval Examination (n)	Frequency Examination (Day)	Downtime/ D (t)
Brake System	39,49	156,56	0,20502	95,45	0,0269
Carbon Brush	80,53	156,56	0,71718	27,29	0,0237
Electric Hoist	47,78	156,56	0,42191	46,38	0,0353
Clutch	76,41	156,56	0,34931	56,03	0,0157
Limit Device	104,90	156,56	0,40928	47,82	0,0122
Stator	75,90	156,56	0,63562	30,79	0,0236

3.5. Availability Analisis

The availability calculation of the predictive maintenance concept has different values for each critical component of the overhead engine, which is based on reliability, as well as the engine maintenance interval. The underlying thing is often the occurrence of damage or the existence of unplanned downtime, it is necessary to do corrective maintenance so that the operational time is idle. The results of the calculation of availability in critical components can be seen in table 6 below:

Table 6. Value of Availability (approval) Treatment

Component Type	Replacement Availability (Ai)	Preventive Availability (A_{tp})	System Availability (A_s (t))
Brake System	0,995796807	0,97303	0,999887
Carbon Brush	0,987734197	0,97630	0,999709
Electric Hoist	0,987937643	0,96467	0,999574
Clutch	0,996738879	0,98425	0,999949
Limit Device	0,99762254	0,98779	0,999971
Stator	0,98914037	0,97634	0,999743

3.6. Predictive Maintenance Costs Analisys

Predictive maintenance (PdM) is a decision-making technique in terms of helping to reduce maintenance costs or costs during the production process. Maintenance costs that often occur due to inefficient management of resources. To reduce maintenance costs by 27,62 %, an effective PDM technique is needed, thereby increasing production capacity. To find out the deviation of the predictive maintenance care system can be seen in table 7 as below:

Table 7. Saving Cost on Overhead Crane Machines

Component type	Cost of Failure /Cf (IDR)	Cost of Predictive Maintenance /CPdM (IDR)	Saving Costs (IDR)	Saving Costs (%)
Brake System	102.569.804	2.037.166	100.532.638	98,01
Carbon Brush	191.195.392	9.055.225	182.140.166	95,26
Electric Hoist	497.926.725	196.081.942	301.844.783	60,62
Clutch	52.154.865	3.956.344	48.198.521	92,41
Limit Device	33.894.810	2.076.826	31.817.984	93,7
Stator	188.393.815	17.557.599	170.836.216	90,68
Total	1.066.135.411	230.765.103	835.370.308	27,62

3.7. Overall Equipment Effectiveness (OEE)

Overall Equipment Effectiveness (OEE) is an indicator of the effectiveness of the resources it has (level of reliability, level of productivity, etc.) using machines or equipment used. OEE itself is obtained from the calculation of the availability of equipment, the work efficiency of a production process, and the ratio of product quality. Implementation in the application of the Overall Equipment Effectiveness (OEE) method by calculating the OEE component

After calculating the Availability Rate, Performance Efficiency and Rate Of Quality, Overall Equipment Effectiveness (OEE) in the company PT. Bromo Steel Indonesia, value can be seen in table 8 as follows:

Table 8. OEE in PT. Bromo Steel Indonesia

Month	Before Predictive Maintenance				After Predictive Maintenance			
	Availability (%)	Performance Efficiency (%)	Quality Rate (%)	OEE (%)	Availability (%)	Performance Efficiency (%)	Quality Rate (%)	OEE (%)
February	98,83	79,41	80,35	86,20	99,11	86,22	80,35	88,56
March	98,92	97,59	98,66	98,39	99,16	97,59	98,66	98,47
April	99,14	71,45	72,06	80,89	99,38	75,21	72,06	82,22
May	98,91	83,37	98,83	93,70	99,15	87,76	98,83	95,25
Juny	98,72	83,07	93,59	91,79	98,95	94,94	93,59	95,82
Average OEE Before Predictive Maintenance				90,19	Average OEE After Predictive Maintenance			92,06

The results of the analysis of the calculation to the overall effectiveness of the equipment (OEE) at PT Bromo Steel Indonesia before the predictive maintenance of 90.19% and after the predictive maintenance of 92.06% an increase of 1.87%.

4. Conclusions

Based on the results of processing and analysis of data obtained the following conclusions:

a. The critical component for engine overhead crane PT. Bromo Steel Indonesia is a brake system, carbon brush, electric hoist, limit device, clutch, spull motor.
b. The distribution pattern used is weibull
c. The optimum maintenance interval for the engine components of the overhead crane is the Brake system for 95 days, carbon brush for 27 days, electric hoist for 46 days, limit device for 47 days, clutch for 56 days, spull motor for 31 days and schedule for replacement of components can be seen in table 5.
d. Changes to the maintenance system from breakdown maintenance to predictive maintenance resulted in savings cost of 22,74% on overhead crane machines components with a nominal value of IDR. 1.051.031.511.
e. The results of the analysis of the calculation to the overall effectiveness of the equipment (OEE) at PT Bromo Steel Indonesia before the predictive maintenance of 90.19% and after the predictive maintenance of 92.06% an increase of 1.87%.

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