Maintenance Management Jacro 175 Drill Rig for Coal Exploration Work Using the Reliability Centered Maintenance (RCM) Method in PT Inti Bangun Mulya

Polii Renaldy Jefli*, Farida Djumiati Sitania
Faculty of Engineering, Mulawarman University, Jl. Sambaliung No. 9 Kampus Gn. Kelua Samarinda, Kalimantan Timur 75119 Indonesia

ARTICLE INFORMATION

ABSTRACT

PT. Inti Bangun Mulya was established in 2019 and is a company engaged in consulting and contracting services in the mining sector, including mapping, topography, mineral exploration, mineral modeling, mine design, mine economic evaluation, and resource and reserve calculation. This research aims to determine the critical components and to identify an effective and efficient maintenance schedule for the Jacro 175 Rig components. In determining critical components and creating a maintenance schedule, the researchers used Reliability Centered Maintenance (RCM) with the application of an appropriate and systematic maintenance system. This research uses a research method employing RCM and Failure Mode and Effect Analysis (FMEA). Data collection techniques include observation, interviews, and questionnaires. The initial steps taken by the author were to identify functions and failures, analyze system failures occurring in the Yanmar TF 105 machine, analyze critical level criteria, analyze FMEA, determine appropriate task selection, calculate the reliability value of critical components, and provide repair proposals in the form of an efficient maintenance schedule for critical components. The results of this study indicate that PT. Inti Bangun Mulya is known to implement a maintenance management system using a corrective maintenance system that is less effective and efficient for application to all components. Therefore, the author proposes an improvement in the form of a maintenance schedule for critical components.

*Corresponding Author

Renaldy Jefli Polii
Email: Renaldyjeflipolii@gmail.com

1. INTRODUCTION

According to the Ministry of Energy and Mineral Resources, one of the key sectors that the Indonesian government relies on to quickly increase national foreign exchange is the mining sector. This sector plays a vital role in boosting national and regional income as well as creating job opportunities for local

communities. Indonesia is known for its abundant natural resources, one of which is coal. Based on data obtained from the Ministry of Energy and Mineral Resources in 2020, East Kalimantan is the largest coal producer in Indonesia. This province contributed 268,449 tons or 47.9% of the total coal extracted in Indonesia. To utilize coal efficiently, a thorough and detailed exploration process is required. Coal exploration activities, particularly during the stages of general exploration and detailed exploration, are closely linked to drilling activities. PT. Inti Bangun Mulya, established in 2019, is a company operating in the field of mining consultancy and contracting services. Their services include mapping, topography, mineral exploration, mineral modeling, mine design, economic evaluation of mines, as well as resource and reserve calculations.

In the exploration/sampling work carried out by PT. Inti Bangun Mulya, one of the main supporting tools used is the Jacro 175 drilling rig. According to Nugraha and Permana (2016), the Jacro 175 drilling rig is an installation of equipment used to drill into underground reservoirs to obtain water, oil, natural gas, or underground mineral deposits. Drilling rigs can be located onshore or offshore, depending on the user's needs. Based on the author's initial observations during their activities, PT. Inti Bangun Mulya often encounters issues with components within the Jacro 175 drilling rig, one of which is the breakdown of the Yanmar TF 105 engine, which is a key driving force for the rig. If any component within the Jacro 175 drilling rig fails, the entire drilling process comes to a halt. This can impede the drilling process, leading to delays in coal sample collection. During the observation, PT. Inti Bangun Mulya was found to be applying a corrective maintenance system, which involves repairing components only after they have broken down. As a result, the Jacro 175 rig experiences prolonged breakdowns.

Reliability Centered Maintenance (RCM) is a process used to determine the necessary actions to ensure that each physical asset continues to function as desired. By implementing a proper and systematic maintenance system, this method can be used to enhance efficiency by reducing maintenance costs while maintaining the reliability of the company's assets. Additionally, the RCM method has the advantage of focusing on critical components or machines (critical item list) and eliminating unnecessary maintenance activities by determining the optimal maintenance intervals (Sembiring, 2018). Therefore, in this study, the author intends to design a maintenance management plan for the Jacro 175 drilling rig. Therefore, a maintenance system is needed that can effectively and efficiently repair the components and machines within the Jacro 175 drilling rig. The Preventive Maintenance method could be a good solution for the maintenance system of the Jacro 175 drilling rig at PT. Inti Bangun Mulya.

2. LITERATURE REVIEW
Maintenance activities play a crucial role in systematic and integrated care, as well as being a supportive factor in ensuring that operational activities run as planned. Proper machine maintenance can also minimize costs by preventing damage before it becomes severe. (Candra, 2020).

According to Sukania and Wijaya (2022), in the analysis using the FMEA method, the priority levels of failure modes are determined. In determining the priority level of failure modes, the calculation of the Risk Priority Number (RPN) can be performed. The Risk Priority Number (RPN) is an indicator to measure the risk of failure modes and determine the priority scale for repairs that should be carried out first. The mathematical product of the severity of the effect (severity) results in the RPN. The occurrence of the cause will allow the emergence of failures related to the effect (occurrence), and the ability to detect before the failure occurs. (detection). In various industries, including manufacturing, risk investigation through FMEA and lean manufacturing approaches such as 5S has made a positive impact in addressing issues of efficiency, product defects, and production costs, (Sumasto et al., (2023).

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According to Susanto and Azwir (2018), Reliability Centered Maintenance (RCM) is called reliability-based maintenance because RCM recognizes that maintenance cannot do more than ensure that assets continuously

achieve their inherent reliability. From an engineering perspective, asset management is divided into two elements: asset maintenance and asset modification, which are efforts to ensure that all physical assets can continue to perform as desired by their users and remain in a ready-to-use condition. The definition of RCM recognizes that the design and operation of equipment vary, resulting in different failure probabilities.

Based on the literature review, most previous studies focus on the application of Reliability Centered Maintenance (RCM) and Failure Mode and Effect Analysis (FMEA) to identify critical components and determine preventive maintenance intervals. However, these studies are generally limited to single case studies and emphasize technical reliability analysis without evaluating the long-term effectiveness of the proposed maintenance schedules under different operating conditions. In addition, the existing literature provides limited discussion on the impact of maintenance strategies on operational performance, downtime reduction, and maintenance costs. The use of conventional RCM–FMEA methods also dominates prior research, with little exploration of alternative or integrated maintenance approaches. Therefore, further research is needed to broaden the scope of analysis and assess maintenance effectiveness in a more comprehensive and practical context.

3. RESEARCH METHOD

This study uses the Reliability Centered Maintenance (RCM) method integrated with Failure Mode and Effect Analysis (FMEA) to analyze and improve the maintenance system of the Jacro 175 drilling rig. The research begins with identifying maintenance problems related to frequent equipment failures and unplanned downtime. Data are collected through observation, interviews with operators and maintenance personnel, questionnaires, and historical failure records. System and functional analyses are conducted to identify component functions and functional failures. FMEA is applied to determine failure modes and calculate Severity, Occurrence, Detection, and Risk Priority Number (RPN) values to identify critical components. Furthermore, Logic Tree Analysis (LTA) is used in the RCM stage to select appropriate maintenance actions. Reliability analysis is then performed by calculating Time to Failure (TTF), Time to Repair (TTR), Mean Time to Failure (MTTF), and Mean Time to Repair (MTTR) using statistical distribution fitting. Based on the reliability results, preventive maintenance intervals are determined, and a preventive maintenance schedule is proposed.

4. RESULT AND DISCUSSION
4.1. Productivity Calculation

The questionnaire data is primary data collected to determine the highest level of failure risk on the Jacro 175 Rig engine, namely the Yanmar TF 105 engine, which can be seen in Table 1. These are results that can be summarized based on the processing of data that has been processed and analyzed.

Table 1. Data of severity, occurrence and detection

Component	Failure Mode	Failure Causes	Severity	Occurrence	Detection
Spring valve	Weak spring capacity		4	2	3
Suction valve	Valvehaving a leak	Cylinderexperiencing expansion	3	4	9
Exhaust valve	Valvehaving a leak		3	4	9
Cylinder head gasket	Gaskethaving damaged		6	4	10
Bearing 6006	Bearingpeeled off	The axle does not rotate	8	6	7
V-pulley	V-pulleyseparated		8	2	6
Piston Ring	worn out		4	6	6
Piston pin	Aww, corrosion	Pump not moving	4	6	6
Bearing crank pin	worn out		8	5	6
Bearing 6005	Aww, eroded	Excessive vibration	8	5	7
Bearing 6009	Aww, eroded		8	5	7
Air cleaner element	Damaged	Engine performance decreases	4	6	3
Pulley fan assembly	Cracked, broken		3	4	6
Vanbelt M1385	Cracked, broken	Overheat	3	6	6
Oil coolant	Mixed with water		2	8	3
Fuel injection nozzle	Blocked	Fuel pumpnot operating	4	6	5
O-ring strainer	Corrosion	Fuel guzzler	3	6	5
Strainer filter element	Damaged		4	6	5

Based on the table above, the severity, occurrence and detection values of each component of the Yanmar TF 105 engine on the Jacro 175 Rig are known.
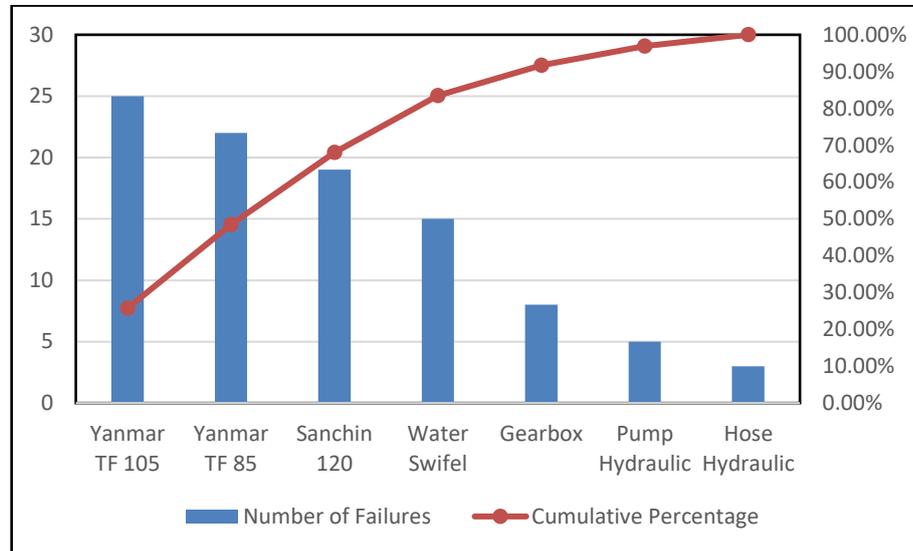
4.2. Identification of Functions and Failures

Figure 1. Functions and failures data

4.3 System Failure Analysis

System failure analysis is a procedure for describing each subsystem and component/equipment and identifying all functions and interfaces with other systems or subsystems by identifying all functional failures.

Table 2. Yanmar TF 105 engine system failure

System	Subsystem	Component	System failure description	Description of subsystem failure	Component failure description
Cylinder Head	Head Assy	Spring valve Suction valve Exhaust valve Cylinder head gasket	Cylinder experiencing expansion	Cylinderexperiencing expansion	Weak spring capacity Valve having a leak Valve having a leak Gasket having damaged
Crankshaft	Camshaft Crankshaft Assembly	Bearing 6006 V-pulley	The axle does not rotate	The axle does not rotate	Bearing peeled off V-pulley separated
Piston	Piston Assembly Rod Assy Connecting	Piston ring Piston pin Bearing crank pin	Pump not moving	Pump not moving	worn out Aww, corrosion worn out
Balancer	Shaft Balancer	Bearing 6005 Bearing 6009	Excessive vibration	Excessive vibration	Aww, eroded Aww, eroded
Air Cleaner	Air Intake	Air cleaner element	Engine performance decreases	Engine performance decreases	Damaged
Fan	Fan Assembly	Pulley fan assembly Vanbelt M1385	Overheat	Overheat	Cracked, broken Cracked, broken
Radiator	Oil Radiator	Oil coolant	Corrosion	Corrosion	Mixed with water
Fuel Injection	Valve Assy Fuel Injection	Fuel injection nozzle	Fuel pumpnot operating	Fuel pumpnot operating	Blocked
Fuel Strainer	Strainer Assy Fuel	O-ring strainer Strainer filter element	Fuel guzzler	Fuel guzzler	Corrosion Damaged

4.4 Failure Mode and Effect Analysis (FMEA)

Table 3. Cumulative percentage of RPN value

Component	RPN	Total (%)	Cumulative (%)
Bearing 6006	336	12.9%	12.9%
Bearing 6005	280	10.8%	23.7%
Bearing 6009	280	10.8%	34.5%
Cylinder head gasket	240	9.2%	43.7%
Bearing crank pin	210	8.1%	51.8%
Piston Ring	144	5.5%	57.3%
Piston pin	144	5.5%	62.8%
Fuel injection nozzle	120	4.6%	67.5%
Strainer filter element	120	4.6%	72.1%
Suction valve	108	4.2%	76.2%
Exhaust valve	108	4.2%	80.4%
Vanbelt M1385	108	4.2%	84.5%
V-pulley	96	3.7%	88.2%
O-ring strainer	90	3.5%	91.7%
Air cleaner element	72	2.8%	94.5%
Pulley fan assembly	72	2.8%	97.2%
Oil coolant	48	1.8%	99.1%
Spring valve	24	0.9%	100.0%
TOTAL	**2600**	**100.0%**	

4.5 Reliability

Reliability calculations are performed on 4 components that have the highest RPN values, these components are Bearing 6005, Bearing 6009 and Cylinder head gasket. To determine the distribution that corresponds to component damage, the index of fit calculation of each component is performed.

1. Bearing 6005

a) Weibull Distribution

$Xi = \ln(ti) = \ln(748.83) = 6.6185$

$F(ti) = \dfrac{i - 0.3}{n + 0.4} = \dfrac{1 - 0.3}{4 + 0.4} = 0.1591$

$Yi = \ln(\ln \dfrac{1}{1 - (F(ti))}) = \ln(\ln \dfrac{1}{1 - (0.1591)}) = -1.7529$

$r = \dfrac{(k\sum_{i=1}^{n} xiyi) - (\sum_{i=1}^{n} xi)(\sum_{i=1}^{n} yi)}{\sqrt{(n(\sum_{i=1}^{n} xi^2) - (\sum_{i=1}^{n} xi)^2)(n\sum_{i=1}^{n} yi^2)(\sum_{i=1}^{n} yi)^2}}$

$r = 0.9690$

b) Lognormal Distribution

$Xi = \ln(ti) = \ln(748.83) = 6.6185$

$F(ti) = \dfrac{i - 0.3}{n + 0.4} = \dfrac{1 - 0.3}{4 + 0.4} = 0.1591$

$Yi =$ obtained from the table $\Phi(z) = 0.5596$

$r = \dfrac{(k\sum_{i=1}^{n} xiyi) - (\sum_{i=1}^{n} xi)(\sum_{i=1}^{n} yi)}{\sqrt{(n(\sum_{i=1}^{n} xi^2) - (\sum_{i=1}^{n} xi)^2)(n\sum_{i=1}^{n} yi^2)(\sum_{i=1}^{n} yi)^2}}$

$r = 0.9555$

c) Exponential Distribution

$Xi = ti = 748.83$

$F(ti) = \dfrac{i - 0.3}{n + 0.4} = \dfrac{1 - 0.3}{4 + 0.4} = 0.1591$

$Yi = \ln(\ln \dfrac{1}{1 - (F(ti))}) = \ln(\ln \dfrac{1}{1 - (0.1591)}) = 0.1733$

$r = \dfrac{(k\sum_{i=1}^{n} xiyi) - (\sum_{i=1}^{n} xi)(\sum_{i=1}^{n} yi)}{\sqrt{(n(\sum_{i=1}^{n} xi^2) - (\sum_{i=1}^{n} xi)^2)(n\sum_{i=1}^{n} yi^2)(\sum_{i=1}^{n} yi)^2}}$

$r = 0.9572$

d) Normal Distribution

$Xi = ti = 748.83$

$F(ti) = \dfrac{i - 0.3}{n + 0.4} = \dfrac{1 - 0.3}{4 + 0.4} = 0.1591$

$r = \dfrac{(k\sum_{i=1}^{n} xiyi) - (\sum_{i=1}^{n} xi)(\sum_{i=1}^{n} yi)}{\sqrt{(n(\sum_{i=1}^{n} xi^2) - (\sum_{i=1}^{n} xi)^2)(n\sum_{i=1}^{n} yi^2)(\sum_{i=1}^{n} yi)^2}}$

$r = 0.9495$

From the validation results of the Weibull, lognormal, exponential and normal distributions, it can be concluded that the calculations from the Minitab software are the same as the manual calculations. *Index of fit*, so it can be concluded that the TTF value of the Bearing 6005 component uses the Weibull distribution.

2. Bearing 6009

a) Weibull Distribution

$Xi = \ln(ti) = \ln(748.48) = 6.6180$

$F(ti) = \dfrac{i - 0.3}{n + 0.4} = \dfrac{1 - 0.3}{4 + 0.4} = 0.1591$

$Yi = \ln(\ln \dfrac{1}{1 - (F(ti))}) = \ln(\ln \dfrac{1}{1 - (0.1591)}) = -1.7529$

$$r = \frac{(k\sum_{i=1}^{n}xiyi) - (\sum_{i=1}^{n}xi)(\sum_{i=1}^{n}yi)}{\sqrt{(n(\sum_{i=1}^{n}xi^2) - (\sum_{i=1}^{n}xi)^2)(n\sum_{i=1}^{n}yi^2)(\sum_{i=1}^{n}yi)^2}}$$

r = 0.9695

b) Lognormal Distribution

Xi = ln(ti) = ln(748.48) = 6.6180

$F(ti) = \frac{i - 0.3}{n+0.4} = \frac{1 - 0.3}{4+0.4} = 0.1591$

Yi = obtained from the table Φ(z) = 0.5596

$$r = \frac{(k\sum_{i=1}^{n}xiyi) - (\sum_{i=1}^{n}xi)(\sum_{i=1}^{n}yi)}{\sqrt{(n(\sum_{i=1}^{n}xi^2) - (\sum_{i=1}^{n}xi)^2)(n\sum_{i=1}^{n}yi^2)(\sum_{i=1}^{n}yi)^2}}$$

r = 0.9563

c) Exponential Distribution

Xi = ti = 748.48

$F(ti) = \frac{i - 0.3}{n+0.4} = \frac{1 - 0.3}{4+0.4} = 0.1591$

$Yi = \ln(\ln\frac{1}{1-(F(ti))}) = \ln(\ln\frac{1}{1-(0.1591)}) = 0.1733$

$$r = \frac{(k\sum_{i=1}^{n}xiyi) - (\sum_{i=1}^{n}xi)(\sum_{i=1}^{n}yi)}{\sqrt{(n(\sum_{i=1}^{n}xi^2) - (\sum_{i=1}^{n}xi)^2)(n\sum_{i=1}^{n}yi^2)(\sum_{i=1}^{n}yi)^2}}$$

r = 0.9582

d) Normal Distribution

Xi = ti = 748.48

$F(ti) = \frac{i - 0.3}{n+0.4} = \frac{1 - 0.3}{4+0.4} = 0.1591$

Yi = Zi = Φ-1 (F(ti)) = 0.5596 obtained from the Standardized Normal Probabilities table

$$r = \frac{(k\sum_{i=1}^{n}xiyi) - (\sum_{i=1}^{n}xi)(\sum_{i=1}^{n}yi)}{\sqrt{(n(\sum_{i=1}^{n}xi^2) - (\sum_{i=1}^{n}xi)^2)(n\sum_{i=1}^{n}yi^2)(\sum_{i=1}^{n}yi)^2}}$$

r = 0.9500

From the validation results of the four distributions, it can be concluded that the calculation of the Minitab software is the same as the manual calculation of the Index of Fit, which means that the TTF value of the Bearing 6009 component uses the Weibull distribution.

Bearing 6005

Based on the results of the Goodness-of-Fit test above, the selected distribution is the Weibull distribution. Furthermore, the distribution will be validated and calculated manually, so that the determination of the distribution using software and manual must have the same value. The manual calculation of the four distributions can be seen as follows.

a) Weibull Distribution

Xi = ln(ti) = ln(45.12) = 3.8093

$F(ti) = \frac{i - 0.3}{n+0.4} = \frac{1 - 0.3}{4+0.4} = 0.1296$

$Yi = \ln(\ln\frac{1}{1-(F(ti))}) = \ln(\ln\frac{1}{1-(0.1591)}) = -1.9745$

$$r = \frac{(k\sum_{i=1}^{n}xiyi) - (\sum_{i=1}^{n}xi)(\sum_{i=1}^{n}yi)}{\sqrt{(n(\sum_{i=1}^{n}xi^2) - (\sum_{i=1}^{n}xi)^2)(n\sum_{i=1}^{n}yi^2)(\sum_{i=1}^{n}yi)^2}}$$

r = 0.8247

b) Lognormal Distribution

Xi = ln(ti) = ln(45.12) = 3,8093

$F(ti) = \frac{i - 0.3}{n+0.4} = \frac{1 - 0.3}{4+0.4} = 0.1296$

Yi = obtained from the table Φ(z) = 0.5478

$$r = \frac{(k\sum_{i=1}^{n}xiyi) - (\sum_{i=1}^{n}xi)(\sum_{i=1}^{n}yi)}{\sqrt{(n(\sum_{i=1}^{n}xi^2) - (\sum_{i=1}^{n}xi)^2)(n\sum_{i=1}^{n}yi^2)(\sum_{i=1}^{n}yi)^2}}$$

r = 0.8496

c) Exponential Distribution

Xi = ti = 45.12

$F(ti) = \frac{i - 0.3}{n+0.4} = \frac{1 - 0.3}{4+0.4} = 0.1296$

$Yi = \ln(\ln\frac{1}{1-(F(ti))}) = \ln(\ln\frac{1}{1-(0.1591)}) = 0.1388$

$$r = \frac{(k\sum_{i=1}^{n}xiyi) - (\sum_{i=1}^{n}xi)(\sum_{i=1}^{n}yi)}{\sqrt{(n(\sum_{i=1}^{n}xi^2) - (\sum_{i=1}^{n}xi)^2)(n\sum_{i=1}^{n}yi^2)(\sum_{i=1}^{n}yi)^2}}$$

r = 0.9059

d) Normal Distribution

Manual calculation of the Index of Fit on a normal distribution can be seen as follows.

Xi = ti = 45.12

$F(ti) = \frac{i - 0.3}{n+0.4} = \frac{1 - 0.3}{4+0.4} = 0.1296$

Yi = Zi = Φ-1 (F(ti)) = 0.5478 obtained from the Standardized Normal Probabilities table So, the calculation of the Index of Fit in the normal distribution can be seen in the following table.

$$r = \frac{(k\sum_{i=1}^{n}xiyi) - (\sum_{i=1}^{n}xi)(\sum_{i=1}^{n}yi)}{\sqrt{(n(\sum_{i=1}^{n}xi^2) - (\sum_{i=1}^{n}xi)^2)(n\sum_{i=1}^{n}yi^2)(\sum_{i=1}^{n}yi)^2}}$$

r = 0.7349

From the validation results of the Weibull, lognormal, exponential and normal distributions, it can be concluded that the calculation of the Minitab software is the same as the manual calculation of the index of fit, so it can be concluded that the TTF value of the Bearing 6005 component uses a lognormal distribution.

4.6 Calculation of Mean Time To Failure (MTTF)

After the selection and testing of each distribution for the Bearing 6005 and Bearing 6009 components based on goodness of fit, the

next step is to determine the parameters and calculate the Mean Time To Failure (MTTF) value. Determination of the selected distribution parameters of the critical components is done using Minitab software. Based on these results, 2 Weibull parameters are obtained, namely scale (θ) and shape (β). The calculation of MTTF from the Bearing 6005 and Bearing 6009 components can be seen in the following:

1. Bearing 6005
   (θ) = 1279.99
   (β) = 1.237315
   So,$(1 + \frac{1}{\beta})$= = $1.2373(1 + \frac{1}{4,21380})$
   MarkГ/gamma (1.2373) = 0.9091127
   So the MTTF value = Scale(θ) x r/gamma value (0.9091127)
   = 1279.99 x 0.9091127
   = 1163.65 hoursor48.4856 days
   So it can be seen that the MTTF value or damage interval time for the 6005 Bearing component is 1163.65 hours or 48.4856 days.

2. Bearing 6009
   (θ) =1279.31
   (β) =1.237811563
   So,$(1 + \frac{1}{\beta})$= =$(1 + \frac{1}{4,20501})$1.237811563
   MarkГ/gamma (1.237811563) = 0.9090025
   So the MTTF value = Scale(θ) x r/gamma value (1.237811563)
   = 1279.99 x 0.9090025
   = 1162.89 hoursor 48,454 days
   So it can be seen that the MTTF value or damage interval time of the 6009 Bearing component is 1162.89 hours or 48.454 days.

4.7 Mean Time To Repair (MTTR) Calculation

After the selection and testing of each distribution for the Bearing 6005 and Bearing 6009 components based on goodness of fit, the next step is to determine the parameters and calculate the Mean Time To Repair (MTTR) value. Determination of the selected distribution parameters of the critical components is done using Minitab software. Based on these results, 2 lognormal parameters are obtained, namely scale and tmed. The calculation of MTTR from the Bearing 6005 and Bearing 6009 components can be seen in the following table.

1. *Bearing 6005*

(θ)   = 0.885786
tmed = 92.8097

So,tmed $[e^{(\frac{s^2}{2})}]$= = $1.480394259 e^{(\frac{0,885786^2}{2})}]$
So the MTTR value = tmed x 1.480394259
= 92.8097 x1.480394259
= 137.3949471 hoursor 5.7248 days
So it can be seen that the MTTR value or damage interval time for the 6005 Bearing component is137.3949471hours or 5.7248 days.

2. Bearing 6009
   (θ)   = 0.885384
   tmed = 92.8939

   So,tmed $[e^{(\frac{s^2}{2})}]$= = $1.479867325 e^{(\frac{0,885384^2}{2})}]$
   So the MTTR value = tmed x 1.479867325
   = 92.8097 x1.479867325
   = 137.4706473 hoursor 5.7279 days
   So it can be seen that the MTTR value or damage interval time for the 6005 Bearing component is137.4706473hours or 5.7279 days.

4.8 Critical Component Reliability Calculation

Based on the results of the Mean Time To Failure (MTTF) calculation, the reliability value of each critical component is then calculated..Reliability calculations for each critical component can be described using Equation 2.11.

1. Bearing 6005
   (θ) = 1279.99
   (β) = 1.237315
   (t) = 1163.655165 hours
   So,$e^{[-(\frac{t}{\theta})^\beta]}$= = $0.32470 e^{[-(\frac{1163,655165}{1279,99})^{1,237315}]}$
   So the Reliability value = 0.32470 or 32.47%
   So it can be seen that the reliability value of the Bearing 6005 component is 0.32470 or 32.47%.

2. Bearing 6009
   (θ) = 1279.31
   (β) = 1.237811563
   (t) = 1162.895988 hours
   So,$e^{[-(\frac{t}{\theta})^\beta]}$= = $0.324596 e^{[-(\frac{1162,895988}{1279,31})^{1,237315}]}$
   So the Reliability value = 0.324596 or 32.46%
   So it can be seen that the reliability value of the Bearing 6005 component is 0.324596 or 32.46%.

Based on the reliability calculations above for each critical component, the following reliability recapitulation table is obtained.From the recapitulation table above, it can be seen that the Bearing 6005 component has a low reliability level of 32.47%. And for the Bearing 6009 component also has a low reliability level of 32.46%.

4.9 Critical Component Preventive Maintenance Intervals

To increase the reliability value of critical components, it is necessary to change the preventive maintenance interval schedule for critical components of the Yanmar TF 105 engine on the RIG Jacro 175.

Bearing 6005

$$H(TP) = e^{\left[-\left(\frac{t}{\theta}\right)^{\beta}\right]}$$
$$= 1 - e^{\left[-\left(\frac{1163,655165}{1279,99}\right)^{1,237315}\right]}$$
$$= 1 - 0.70610$$
$$= 0.29390$$

Bearing 6009

$$H(TP) = e^{\left[-\left(\frac{t}{\theta}\right)^{\beta}\right]}$$
$$= 1 - e^{\left[-\left(\frac{1162,895988}{1279,31}\right)^{1,237315}\right]}$$
$$= 1 - 0.70587$$
$$= 0.29413$$

It can be seen that if the Bearing 6005 component wants to have a reliability value of 70%, then preventive maintenance must be carried out every 360 hours or 15 days.

5. CONCLUSION

Based on the TTF and TTR data, the MTTF and MTTR values of the two components are calculated by first determining and testing the distribution. Determination and testing are carried out using Minitab software and manual calculations. So it is found that the distribution of the TTF data of the two components uses the Weibull distribution, while the TTR data of the two components uses the lognormal distribution. Furthermore, the MTTF and MTTR values of the two components can be calculated. The MTTF value of the 6005 bearing component is 1163.65 hours or 48.4856 days and the MTTF value of the 6009 bearing is 1162.89 hours or 48.454 days. While the MTTR value of the 6005 bearing component is 137.3949471 hours or 5.7248 days and the MTTR value of the 6009 bearing component is 137.4706473 hours or 5.7279 days. So the next

Likewise, for the Bearing 6009 component, if it wants to have a reliability value of 70%, then preventive maintenance must be carried out every 360 hours or every 15 days.

The results of this study provide practical benefits for industry in improving maintenance management of drilling equipment. By applying the Reliability Centered Maintenance (RCM) and Failure Mode and Effect Analysis (FMEA) methods, companies can systematically identify critical components and determine appropriate preventive maintenance intervals. This enables maintenance activities to be prioritized based on component criticality, thereby reducing unplanned downtime and improving equipment reliability during drilling operations.

Furthermore, the reliability-based maintenance intervals obtained in this study can support more effective maintenance scheduling and resource allocation. The proposed maintenance approach allows companies to move away from purely corrective maintenance practices toward a structured preventive maintenance system. The research findings may also be used as a reference for similar industrial equipment or operations seeking to implement reliability-based maintenance strategies.

step is to calculate the reliability of the two components. The results of the reliability calculations show that both components have low reliability values, namely the component*bearing 6005*of 0.32470 or 32.47% and the reliability value of bearing 6009 of 0.324596 or 32.46%. Future research should evaluate the effectiveness of the proposed RCM-based preventive maintenance schedule through post-implementation analysis by comparing reliability and downtime before and after application. In addition, further studies may expand the analysis to multiple equipment units and incorporate maintenance cost and alternative maintenance strategies to obtain more comprehensive results.

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