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Planning of Preventive Maintenance Time Interval on Rubber Tyred Gantry Unit Using Relability Centered Maintenance (RCM) II

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Abstract: PT Pelabuhan Indonesia (Persero) is one of the gateways for ships and goods both domestically and export-import. In the operation of the Rubber Tyred Gantry (RTG), several cases of problems were encountered that could hinder or disrupt the loading and unloading process caused by the incompatibility of the maintenance schedule provided by the company for the equipment used. The purpose of this study is to determine the time schedule for the maintenance interval of the Rubber Tyred Gantry unit on critical components that often experience damage, and determine a maintenance strategy to anticipate sudden damage to critical components. This study uses the Reliability Centered Maintenance (RCM) II method with critical component analysis using Failure Mode and Effect Analysis (FMEA). The results of this study are maintenance intervals based on the RCM II Decision Worksheet for critical components that have potential failures, including Engine components with preventive maintenance intervals every 16 days a month or 23 times a year, Spreader components with preventive maintenance intervals every 10 days a month. or 36 times a year and Trolly Brake components with preventive maintenance intervals every 13 days a month or 28 times a year during machine operating hours and Strategies to reduce damage to RTG units based on the RCM II Decision Worksheet on RTG unit maintenance using a preventive maintenance strategy by a combination of corrective maintenance where preventive maintenance is carried out according to a predetermined maintenance interval schedule and corrective maintenance is carried out by preparing spare parts that must be replaced when carrying out preventive maintenance checks.

Keywords: Critical Components RTG, Failure Mode and Effect Analysis, Reliability Centered Maintenance (RCM) II

1. Introduction

PT Pelabuhan Indonesia (Persero) is referred to as one of the gateways for ships and goods both domestically and export-import. Makassar Container Terminal is one of the core business segments at PT Pelabuhan Indonesia (Persero). Generally, policies aimed at basic policies regarding efficiency, time effectiveness, and customer satisfaction are a service policy set by the Makassar container terminal. One of the things that can support equipment operating activities in a company is the readiness and performance of its operating machines [1].

Rubber Tyred Gantry (RTG) is a lifting equipment / crane that moves rubber wheels / tires and is used to lift, raise and lower crates from the Head Trailer chassis to the field on the spot and vice versa. In the operation of the Rubber Tyred Gantry (RTG), several cases were encountered which could hinder or disrupt the dismantling process caused by the mismatch of maintenance scheduling provided by the company to the equipment used so that when damage occurs it will result in downtime and higher repair costs.

Maintenance is defined as a strategy in carrying out maintenance to maintain the reliability of a machine which aims to avoid or prevent disturbances to the machine so that an efficient state is obtained as expected by its users. In addition, human resources as the main component in the work system related to interaction with machines imply the operator in carrying out his work, both the operation of the tool and its maintenance system [9]. The maintenance carried out is expected to be able to extend the period of use and ensure the readiness to use the equipment in order to ensure the safety and security of its users [15].

According to Sajaradj dkk, maintenance is a repetitive routine work, which is required to maintain an equipment in a state where it can perform its intended function [11]. Maintenance performed this can be in the form of replacing components or carrying out a thorough inspection within a certain period of time [10].

Damage patterns can be divided into 3 categories, namely [4], Burn – In Period category, at T0 – T1 category, Useful Life Period category, at T1 – T2, and Wear – Out Period category, at T2 – T∞.

In carrying out machine maintenance several ways that can be used, namely, Preventive maintenance which is maintenance that is scheduled and carried out before the occurrence of damage to a part of the machine or equipment. Breakdown Maintenance is defined as maintenance carried out by using the machine/equipment until it malfunctions, then repair or replacement of components is carried out [6]. Treatment is carried out according to a predetermined maintenance schedule. Predictive maintenance is maintenance that is carried out by conducting periodic checks on machine components while corrective maintenance is a maintenance activity that can be used to overcome the occurrence of failures or damage that occurred during preventive maintenance carried out in this case by replacing components [2].

Reliability Centered Maintenance (RCM) is machine maintenance methods related to the reliability of a machine or equipment carried out to obtain an effective maintenance strategy [12]. In September 1990, RCM II was launched which was the result of the previous RCM method development process with the addition of decision worksheet tools and decision diagrams. When compared to the previous RCM, RCM II has a more detailed, broad and complete scope which consists of 4 categories that can be used to determine machine maintenance actions in RCM II. The categories include Hidden (H), Safety (S), Environment (E), and Operational (O), while in the previous RCM method there were only 3 categories, namely Evident, Safety, and Outage [7]. This method has been introduced to industries outside the aeronautical industry by John Moubray, therefore this method can be used on all types of engines. So with its application, it is hoped that it can be used to form a safe reliability system and an effective maintenance schedule can be obtained based on the daily report data that has been carried out which has been assessed qualitatively and quantitatively (Maintenance task) [14].

The purpose of RCM is to establish a design priority to facilitate effective maintenance activities, plan safe and reliable preventive maintenance at certain levels of the system, collect data related to item repair based on evidence of unsatisfactory reliability [13].

To find out the cause of system or equipment damage, the Failure Mode and Effect Analysis (FMEA) method is used which can assist in the development of mitigation strategies, and is used to determine the effects of failures that occur [8]. This method is useful in improving design quality, reliability, and maintainability, and is an important analytical component in risk management [3].

In FMEA, a Risk Priority Number (RPN) can be calculated to determine the highest failure rate. The RPN consists of three variables, namely Severity (severity of damage), Occurrence (frequency of events), Detection (failure detection) which indicates the level of risk that leads to corrective action [5].

In the operation of the Rubber Tyred Gantry (RTG), problems often occur where maintenance is carried out after a breakdown occurs, resulting in delays in the machine's operational process. Problems that occur are generally caused by inappropriate maintenance schedules set by the company for the equipment used which causes downtime and an increase in damage repair costs. Damage that often occurs is damage to engine components, spreaders, and trolly brakes which results in an increase in the percentage of downtime.

To reduce the risk of these problems, a maintenance management is needed to increase the reliability of the tool so that it can prevent and overcome the occurrence of damage. One method that can improve machine reliability is Reliability Centered Maintenance (RCM). This method is an effective approach in carrying out scheduled maintenance so as to minimize failures that can occur.

2. Research Methods

2.1. Research Time and Place

The time of the research was carried out in December starting from 01 to 31 2021 while the research location was at PT. Pelabuhan Indonesia IV (Persero) Makassar Container Terminal is located on Jl. Archipelago No. 329, Pattunuang, Kec. Wajo, Makassar City, South Sulawesi.

2.2. Data Collection

2.2.1. Primary Data

Primary data in the form of direct observations made in the container yard regarding the current maintenance system and the condition of loading and unloading machines.

2.2.2. Secondary Data

Secondary data in the form of data obtained from monthly report archives containing time of machine breakdown, number of machine breakdowns, machine repair time, and working hours data.

2.3. Data Processing

The data processing used in this study uses the Failure. method Modes and Effects Analyze (FMEA) and reliability centered maintenance (RCM) II, namely:

1. Calculation of Unit Damage Downtime.
2. Failure Modes and Effects Analyze (FMEA).
3. Reliability Centered Maintenance (RCM) II Decision Worksheet.
4. Component Damage Downtime Calculation.
5. Calculation of damage time and damage repair time (TTF and TTR).
6. Identification of Distribution for Time to Failure.
7. Goodness of Fit Test for Time to Failure (TTF) and Time to Repair (TTR).

8. Calculation of Time to Failure (TTF) Parameters.
9. and Time to Repair (TTR).
10. Calculation of Mean time to Failure (MTTF) and Time to Repair (MTTR).
11. Calculation of critical component maintenance interval.

3. Results and Discussion

3.1. Failure Modes and Effects Analyze (FMEA)

In this calculation, the rating value is used which describes the damage that occurs to the unit components during the operational process. The following is the rating value used to calculate the total Risk Priority Number (RPN), including severity, occurrence, and detection.

Where:

S = severity with a rating of 1-10

O = occurrence with a rating of 1-10

D = detection with a rating of 1-10

$$RPN = S \times O \times D = 2 \times 1 \times 2 = 4$$

Table 1. *Failure Modes and Effects Analyze (FMEA) Critical Components in the RTG Unit.*

FMEA Worksheet			**System: RTG Engine**						
Part/Process	**Function**	**Potential Failure Mode**	**Potential Effect Of Failure**	**Sev (1-10)**	**Potential Couse Of Failure**	**Occ (1-10)**	**Current Controls**	**Det (1-10)**	**RPN**
Engine	Generate power	Can't start	no power	8	RTG Failed to operate	2	Change the battery	4	64
	Giving power	Over Speed	If left for a long time can damage the engine	5	Power supply is interrupted	1	Check and restart the engine	4	20
Total									84
Spreader	Gripping the container	Can not lock/unlock	Can't lock the container	7	Spreader operation interrupted	2	Replace limit switch, twist lock and repair pump	3	42
		Can not for 20 ft / 40 ft	Cannot span 20 ft / 40 ft	7			Replace telescopic and repair pump	2	28
Total									70
Trolley brake	Braking or stopping Trolley movement	Trolley movement is hard to stop	Cannot brake properly	7	Trolley movement of the system is interrupted	2	Change brake	4	56
Total									56

It can be seen from the Failure Modes and Effects Analyze (FMEA) table that the highest total RPN value is found in 3 components, namely the Engine with an RPN value of 84, Spreader with an RPN of 70, and Trolly Brake with an RPN of 56. From the results of FMEA calculations the treatment will then be carried out using RCM II.

3.2. Reliability Centered Maintenance (RCM) II Decision Worksheet

Reliability Centerd Maintenance (RCM) II Decision Worksheet is used to find the right type of maintenance task and has the possibility to overcome each failure mode.

Table 2. *RCM II Decision Worksheet.*

RCM II Decision Worksheet			**System: RTG unit operation**					
No.	**Component**	**Function**	**Potential Failure Mode**	**Potential Effect Of Failure**	**Potential Couse Of Failure**	**Consequences of Failure**	**Action Given**	**Treatment Measures Performed**
1	Engine	Generating power for RTG	Can not start	no power	RTG failed to operate	Operational Consequences	Conducted Inspection and Detection of Potential Failures	Component replacement
		Giving power	Over speed	If you leave it for a long time, it can damage the engine	Power supply is interrupted			
2	Spreader	Gripping the container	Can not lock/unlock	Can't lock the container	Spreader operation interrupted	Operational Consequences	Conducted Inspection and Detection of Potential Failures	Component replacement
			Can not for 20 ft / 40 ft	Cannot span 20 ft / 40 ft				
3	Trolley brake	Braking or stopping Trolley movement	Trolley movement is hard to stop	Cannot brake properly	Trolley movement of the system is disturbed	Operational Consequences	Conducted Inspection and Detection of Potential Failures	Component replacement

In the RCM II Decision Worksheet table it can be seen where the RTG unit maintenance for critical components is determined based on the type of failure and the cause of the failure.

3.3. Calculation of Damage Time (TTF) and Calculation of Damage Repair Time (TTR)

The repair time interval or time to repair (TTR) is the time interval from the initial occurrence of the damage until it is repaired, while the time to failure (TTF) is a calculation from the end of the previous damage to the time of the next damage.

Table 3. *TTF and TTR Calculation Results for Critical Components.*

No	Component					
	Engine		*Spreader*		*Trolly Brake*	
	TTR (Hour)	TTF (Hour)	TTR (Hour)	TTF (Hour)	TTR (Hour)	TTF (Hour)
1	4:55		2:00		5:05	
2	3:00	122.25	4:00	425.00	3:00	2639.25
3	3:00	14.83	2:00	801.00	1:00	1174.00
4	2:00	1424.00	3:00	51.00		
5	2:00	1854.00	2:00	1910.00		
6	2:00	44.00				
7	3:55	226.08				

3.4. Distribution Test for Time to Failure

To be able to determine the appropriate distribution for time to failure data, an index of fit is calculated for each distribution and the distribution selection is based on the largest index of fit value for each component**.**

Table 4. *Calculation Results of Index of Fit (r) TTF.*

Index Of Fit			
Component Name	Exponential Distribution	Lognormal Distribution	Weibull distribution
Engine	0.95	0.95	0.97
Spreader	0.96	0.91	0.97
Trolly Brake	1.00000	1.00016	1.00000

3.5. Goodness of Fit Test for Time to Failure (TTF)

A. Test Goodness of Fit Test Engine Components Weibull Distribution

The tested hypotheses are:

H_0: Weibull distributed data

H_1: The data are not distributed weibull

H_0 is accepted if the calculation result $M < F_{erit}$

Significance level = 0.05, V1 = 6 and V2 = 5

The results of data processing are M = 1.20 and $F_{erit} = 4.95$.

B. Goodness of Fit Test for Weibull Distribution Spreader Components

The hypotheses tested are:

H_0: Weibull distributed data

H_1: The data are not distributed weibull

H_0 is accepted if the calculation result $M < F_{erit}$

Significance level = 0.05, V1 = 4 and V2 = 3

The results of data processing are M = 1.33 and $F_{erit} = 9.12$.

C. Goodness of Fit Test Lognormal Distribution

The tested hypotheses are:

H_0: Data is lognormally distributed

H_1: The data are not lognormally distributed

H_0 is accepted if the calculation result is $Dn < D_{erit}$

The level of significance = 0.05 and n = 2

The results of data processing are Dn = 0.500 and D_{erit} = 0.842.

3.6. Distribution Test for Time to Repair

To be able to determine the appropriate distribution for time to failure data, an index of fit is calculated for each distribution and the distribution selection is based on the largest index of fit value for each component.

Table 5. *Calculation Results of Index of Fit (r) TTR.*

Index Of Fit			
Component Name	Exponential Distribution	Lognormal Distribution	Weibull distribution
Engine	-0.74	-0.28	-0.22
Spreader	-1.07	-0.10	0.29
Trolly Brake	-0.65	-0.65	-0.38

3.7. Goodness of Fit Test for Time to Repair (TTR)

A. Test Goodness of Fit Test Engine Components Weibull Distribution

The hypotheses tested are:

H_0: Weibull distributed data

H_1: The data are not distributed weibull

H_0 is accepted if the calculation result M < F_{erit}
Significance level = 0.05, V1 = 7 and V2 = 6
The results of data processing are M = 1.17 and F_{erit} = 4.21.

B. Goodness of Fit Test for Weibull Distribution Spreader Components

The hypotheses tested are:
H_0: Weibull distributed data
H_1: The data are not distributed weibull
H_0 is accepted if the calculation result M < F_{erit}
Significance level = 0.05, V1 = 5 and V2 = 4
The results of data processing are M = 1.25 and F_{erit} = 5.19.

C. Goodness of Fit Test Trolly Brake Components Weibull Distribution Components

The hypotheses tested are:
H_0: Weibull distributed data
H_1: The data are not distributed weibull
H_0 is accepted if the calculation result M < F_{erit}
Significance level = 0.05, V1 = 3 and V2 = 2
The results of data processing are M = 1.50 and F_{erit} = 19.16.

3.8. Time to Failure (TTF) Parameter Calculation

In the calculation phase of the time to failure (TTF) parameter, b is called the gradient and a is the intercept. The parameter is called the shape parameter or weibull slope, while the parameter is called the scale parameter or life characteristic.

Table 6. *The calculation results of Time To Failure (TTF) and Time To Repair (TTR) parameters.*

Parameter	Component	Distribution	Time (Hour)
Time To Failure (TTF)	Engine	Weibull	250.12
	Spreader	Weibull	482.11
	Trolly Brake	Lognormal	1198.02
Time To Repair (TTR)	Engine	Weibull	2.07
	Spreader	Weibull	5.39
	Trolly Brake	Weibull	1.64

3.9. Calculation of Mean Time to Failure (MTTF) and Mean Time to Repair (MTTR)

After calculating the parameters, the next step is to calculate Mean Time To Failure (MTTF) and calculate Mean Time To Repair (MTTR) on Engine, Spreader, and Trolley Brake components according to their respective distributions.

Table 7. *Calculation results of Mean Time To Failure (MTTF) and Mean Time To Repair (MTTR).*

No.	Component	MTTF (Hours)	MTTR (Hours)
1	*Engine*	394.28	4.12
2	*Spreader*	540.31	10.09
3	*Trolly Brake*	1308.32	14.44

3.10. Determination of Component Maintenance Interval

The next stage is determining the maintenance interval. Determination of the maintenance time interval aims to determine the optimal time for component maintenance, the calculation results are as follows:

1. Engine = 336.95 hours = 16 days.
2. Spreader = 215.31 hours = 10 days.
3. Trolly Brake = 274.92 hours = 13 days.

4. Conclusions and Recommendations

4.1. Conclusion

Based on the data collection, processing, and analysis that has been done. Then it can be concluded that:

1. Maintenance intervals based on the RCM II Decision Worksheet for critical components that have potential failures, including Engine components with preventive maintenance intervals every 16 days a month or 23 times a year, Spreader components with preventive maintenance intervals every 10 days a month or 36 times a month a year and Trolly Brake components with preventive maintenance intervals every 13 days a month or 28 times a year during machine operating hours.
2. A strategy to reduce the occurrence of damage to the RTG unit based on the RCM II Decision Worksheet on the maintenance of the RTG unit using a preventive maintenance strategy with a combination of corrective maintenance where preventive maintenance is carried out according to a predetermined maintenance interval schedule and corrective maintenance is carried out by preparing spare parts that must be replaced on when carrying out preventive maintenance checks.

4.2. Recommendations

There are several suggestions given to companies are:

1. The company is expected to record or access in full all the damage that occurred to the RTG unit so that a program on reliability, maintenance schedules, component replacement, and inventory can be made correctly.
2. For components that are still undergoing breakdown maintenance, it is expected to take preventive maintenance actions intensively to avoid damage that can affect the cessation of the machine's operational process.

References

[1] Asripa, ashury, and firman husain. 2019. “analysis of container handling systems in containers.” 76–85.

[2] Atma, and hediyanto. 2017. “best practice corrective maintenance activities for bearing damage on millac 5h 6p machines based on knowledge conversion.” Proceedings of snti and satellite 2017 2017 (july 2018): c1-7.

[3] Banghart, marc, and kari babski-reeves. 2018. “subjectivity in failure mode effects analysis (fmea) severity classification within a reliability centered maintenance (rcm) context.” International journal of aviation, aeronautics, and aerospace 5 (1).

[4] Ela patriana & nurismalatri, 2018. 2008. “jurnal teknologi, jurusan teknik industri, fakultas teknologi industri, ist akprind yogyakarta.” [technology journal, department of industrial engineering, faculty of industrial technology, ist akprind Yogyakarta] 11 :(1) 49 المجلـــــــد. Https://www.bertelsmannstiftung.de/fileadmin/files/bst/publikationen/grauepublikationen/mt_globalization_report_2018.pdf%0ahttp://eprints.lse.ac.uk/43447/1/india_globalisation%2csocietyandinequalities%28lsero%29.pdf%0ahttps://www.quora.com/what-is-the.

[5] Ibrahim, taiyeb. 2019. “maintenance of decision engineering programs in the distribution of sea water pump in pt. Kmi with the rcm-ii approach.” International journal of engineering, information science and applied sciences (ijeis-as 2 (1): 1–10. https://journal.stkipsingkawang.ac.id/index.php/ijeis-as/article/view/907.

[6] Kurniawan, and rani. Complicated. 2014. “urbannyte engine maintenance system planning using reliability centered maintenance ii (rcm ii) method.” Undip journal 3 (4): 1–8.

[7] Munawir, hafidh, dan dani yunanto. 2014. “analisa penyebab kerusakan mesin sizing baba sangyo kikai dengan metode fmea dan lta (studi kasus di pt primatexco indonesia).” [analysis of the causes of damage to the Baba Sangyo Kikai sizing machine using the FMEA and LTA methods (case study at PT Primatexco Indonesia)]. *Seminar nasional ienaco*: 296–302.

[8] Nasution, hamidah, dan shinta martina. 2013. “teknik sipil-institut teknologi medan.[civil engineering-field technology institute].

[9] Padhil, A., Pawennari, A., Dahlan, M., & Awaliah, N. R. (2018). “Usulan Perbaikan Lingkungan Kerja Pada Bagian Mesin Puffing Gun Di Ikm Bipang Putri Sehati Kabupaten Gowa”. [Proposed Improvement of the Working Environment on Puffing Gun Machine Parts at Ikm Bipang Putri Sehati, Gowa Regency]. *Journal of Industrial Engineering Management*, *3* (1), 1. https://doi.org/10.33536/jiem.v3i1.197

[10] Rislamy, achmad fany, nina aini mahbubah, dan dzakiyah widyaningrum. 2020. “juli 2020 analisis risiko kerusakan pada alat berat grab dengan metode failure mode and effect analysis (study kasus : pt siam maspion terminal gresik “[july 2020 analysis of the risk of damage to heavy grab equipment with the failure mode and effect analysis method (case study: pt siam maspion terminal gresik)].” 8 (1).

[11] Sajaradj, zulaikha, listiani nurul huda, dan sukaria sinulingga. 2019. “the application of reliability centered maintenance (rcm) methods to design maintenance system in manufacturing (journal review).” *Iop conference series: materials science and engineering* 505 (1).

[12] Supriyadi, supriyadi, resa miftahul jannah, and rizal syarifuddin. 2018. “centrifugal machine maintenance planning using the reliability centered maintenance method at refined sugar companies.” Jisi: journal of industrial system integration 5 (2): 139–47.

[13] Suwandy. R, 2019. “Analisa perawatan mesin *digeste* dengan metode *reliability centered maintenance (rcm)* pada ptpn ii pagar merbau. Skripsi. Medan: univeritas medan area”. [Analysis of digeste machine maintenance using the reliability centered maintenance (rcm) method at PTPN II Pagar Merbau. Essay. Medan: field university area].

[14] Yanuar, almira rahma, and bambang purwanggono. 2015. “proposed optimal treatment program using reliability centered maintenance ii (rcm ii) system in p1 filling point ii filling shed i system (case study of tbbm semarang group pt. Pertamina (persero) supply & distribution region iv central java area.” Journal of industrial engineering 4 (1): 1–7.

[15] Zein, ikramullah, dewi mulyati, and ilham saputra. 2019. “planning for compressor engine maintenance at pt. Es muda perkasa with the reliability centered maintenance (rcm) method.” Journal of serambi engineering 4 (1): 388.