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Proposed Maintenance Planning for Screw Press Machines Using the Reliability Centered Maintenance (RCM) Method at PT. SIR

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A B S T R A C T

PT. SIR is one of the manufacturing companies engaged in processing oil palm fruit into crude palm oil (CPO) and Palm Kernel (PK) with a processing capacity of 45 tons/ hour. From the results of interviews and observations, it was found that the problem that occurred in the company was frequent sudden damage to the srew press machine which resulted in the machine and the production process stopping. The method used in this research is Reliability Centered Maintenance (RCM). The purpose of this research is to identify critical components on the srew press machine, develop a proposed maintenance schedule for each critical component at the Screw Press station, and provide recommendations on the type of periodic maintenance activities for critical components at the Screw Press station. From the results of the research obtained 5 critical components of the srew press machine which are recommended improvements from namely, bearings, shaft press, worm srew, press cage, and spur gear obtained Proposed maintenance schedule for each critical component, namely, on the bearing component the average damage time is 403 hours and the proposed maintenance schedule is 320 hours. Shaft press components average damage time 649.29 and proposed maintenance schedule 470 hours. Worm Srew components average damage 365.58 hours and proposed maintenance schedule 285 hours. Press Cage components average damage 737.5 hours and proposed maintenance schedule 570 hours. Spur Gear components average damage time 671.2 hours and proposed maintenance schedule 520 hours.

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1. INTRODUCTION

The rapid growth of industry, especially in the manufacturing sector, encourages companies to continue to increase productivity in their production systems. In the production process, there are input and output elements. In order for production activities to run smoothly, regular and consistent machine maintenance is needed to optimize the desired results, so that this will provide benefits from the economic and financial aspects for the company. Scheduled maintenance can reduce the risk of unexpected machine failures (breakdowns), thereby reducing production downtime or machine usage. The purpose of this maintenance is to maintain the reliability of the machine so that when the processing process takes place, the machine can operate smoothly. (Wibowo, et al., 2021).

PT. SIR is one of the industries engaged in the manufacturing industry of palm fruit processing which produces CPO (Crude Palm Oil). In this study, observations and interviews were conducted with maintenance assistants and production staff. It was found that in the production process, there was a significant problem, namely the frequent occurrence of breakdowns on the Screw Press machine. This machine generates the largest downtime among all production machines, which results in the obstruction of the production process and a decrease in the processing capacity of fresh fruit bunches processing capacity. In this study, observations and interviews were conducted with maintenance assistants and production staff

The phenomenon that is the focus of this research is the high level of breakdowns on the Screw Press machine at PT Surya Intisari Raya (PT SIR), which has a direct impact on reducing the achievement of factory production capacity. Based on 2023 operational data, the Screw Press machine recorded the highest downtime compared to other machines, reaching 304 hours.
The following is the downtime data for each production station

Table 1. Production machine downtime in 2023

No	Machine Identification	Downtime
1	Sterilizer	63
2	Thresher	201
3	Digester	190
4	**Srew Press**	**304**
5	Clarification	155
6	Boiler	187,5
7	Ripple Mill	102

PT. SIR implements a corrective maintenance system, which is a type of maintenance that is carried out when damage or incidents occur in the system or component. In addition, maintenance is also supported by planned maintenance, which is a routine maintenance schedule that is carried out every week for all machines and environments at each station. The impact caused by machine failure is the occurrence of downtime, which causes the cessation of production operations for a certain period. This can reduce production capacity and reduce the target to be achieved Reliability Centered Maintenance (RCM) is a method used to design maintenance programs with a focus on the reliability and performance of equipment systems. The purpose of this method is to identify actions that need to be taken so that the equipment can operate according to its function. By applying RCM, companies can optimize maintenance strategies, minimize downtime, and improve operational efficiency, so that equipment can function optimally and meet production needs (Sinaga, et al., 2021). Maintenance concepts such as Reliability Centered Maintenance (RCM) have been successfully applied in the process industry to reduce unnecessary preventive maintenance actions and produce more systematic and efficient maintenance plans. RCM is the most structured and effective method of managing a comprehensive programmatic approach to optimize the maintenance of plant and equipment (Azid, et al, 2019).

Reliability Centered Maintenance (RCM) is an approach that primarily aims to reduce costs, improve asset reliability, and provide organizations with an understanding of the level of risk of failure they face. RCM is a structured process, designed to design efficient and effective maintenance plans to reduce the likelihood of failure, while taking into account environmental, safety, operational, and cost analysis factors (Martins, et al, 2020). Therefore, to minimize the damage experienced by the machine, researchers try to propose a machine maintenance strategy through maintenance scheduling of the main components on the Screw Press machine using the Reliability Centered Maintenance (RCM) method.

2. LITERATURE REVIEW

Maintenance is an effort made to maintain the reliability, physical condition, performance, age, and life of the machine so that it remains optimal and can operate properly. Machine maintenance has an important role in the production process in a company, aiming to prevent damage, reduce the risk of failure, and ensure that the machine can function optimally and efficiently in accordance with the desired target. (Pasaribu, et al., 2021). Maintenance is also supporting activities that ensure the continuity of machines and equipment so that whenneeded can be used as expected (Leke & Saifuddin, 2024).

Preventive maintenance is an approach to maintenance management that aims to prevent damage or failure of equipment and machinery through the implementation of planned and routine maintenance (Syaripudin, et al, 2022)
Screw presses play an important role in the palm oil industry. The function of the screw press is to extract the crude oil from the loose fruits that have been chopped, broken, and pulverized in the digester. The screw press consists of two spiral-shaped mixed iron rods (screws) arranged horizontally and rotating in opposite directions. (Purba, et al., 2023).

Reliability Centered Maintenance (RCM) is a method in maintenance designed to improve the reliability of systems and equipment in industry. RCM focuses on identifying the most effective maintenance measures to ensure the reliability and best performance of a system or equipment. (Cahyani and Iftadi, 2021). Reliability Centered Maintenance (RCM) It is a structured process required to ensure all physical facilities can operate optimally according to their design and function. Given the impact it can have, in 1990, RCM II was launched as a result of the development of the previous RCM, with the addition of safety and environmental factors as part of the decision-making consequences (Sajaradj, et al, 2019). Some steps in the RCM process are divided into several parts (Raharja, et al., 2021): (1) Selection and Collection of Information, (2) Definition of System Boundaries, (3) System Diagram and Function Block Diagram, aims to identify and display the function blocks that make up a system, (4) FMEA (Failure Mode and Effect Analysis), analyzes various failure modes of a system consisting of several parts and evaluates their impact on system operations. In addition, the FMEA also calculates the Risk Priority Number (RPN) value, which is used to measure relative risk. In the FMEA analysis, the RPN value is calculated based on the severity, occurrence, and detection values, the following formula is used (Nurjannah, et al., 2023): (a) Severity, refers to the level of impact or intensity generated by the overall machine failure. (b) Occurance, the number of faults that occur in a component, resulting in system failure, or can be understood as the probability of a fault occurring. (c) Detection, indicates the extent to which the failure can be identified before or right at the time of the event.

FMEA is a structured tool used to determine the results the repercussions of a system failure and to prevent prospective failures (Dahlia, et al, 2024)

1. Logic Tree Analysis (LTA)
   The next step is to carry out the Logic Tree Analysis (LTA) method, which is to divide the failure modes into various categories so that the priority level of dealing with each failure mode can be determined based on its category. The LTA method uses a qualitative approach, here are some categories in the LTA analysis (Firsya, et al., 2024). (a) Category A (Safety Problem), failures that threaten operator safety. (b) Category B (Outage Problem), a failure that causes the machine to stop operating. (c) Category C (Economic Problem), failures that cause losses in economic aspects. (d) Category D (Hidden Failure), component failures that are difficult to detect by operators.
2. Task Selection,
   Action selection as the last step in the RCM process. For each damage mode, a list of effective steps to be taken next is compiled. In the implementation of action selection, there are four approaches that can be used, namely (Suwandy, 2019): (1) Time-Directed (TD): Maintenance that is directly directed at preventing failure or damage. (2) Condition-Directed (CD): Maintenance that focuses on detecting failures or symptoms of damage. (2) Failure-Finding (FF): Maintenance that aims to identify hidden failures.

Reliability
Reliability is the condition in which a system, machine, or component can operate properly within a certain period of time, provided that it is used in accordance with the specified operating conditions in a certain environment, without experiencing malfunction or damage (Simanungkalit, et al., 2023).

Reliability evaluation and planned maintenance need to be performed to prevent loss of equipment or system availability. This will assist flow station managers in optimizing system performance as well as maintenance tasks. The main challenge is to predict when or if a failure will occur while the equipment is in use (Omozuhiomwen, et al, 2025).

Distribution of Damage

The distributions applied in this study to determine MTTF and MTTR include normal, lognormal, exponential and weibull distributions:

1. Normal distribution, This distribution is used to describe situations where the effect of a randomness is produced by a small number of independent random variations. (Sinaga, et al., 2021).
   a. Probability Density Function Normal
   $$f(t) = \frac{1}{\sqrt{2\pi\sigma}} \exp\left[-\frac{1}{2}\frac{(t-\mu)^2}{\sigma 2}\right] \quad (1)$$
   b. Reliability Function
   $$R(t) = 1 - \phi\left(\frac{t-\mu}{\sigma}\right) \quad (2)$$
   c. Cumulative Distribution Function
   $$F(p) = \phi\left(\frac{t-\mu}{\sigma}\right) \quad (3)$$
   d. Damage Rate Function
   $$H(t) = \frac{f(t)}{R(t)} \quad (4)$$
2. Lognormal Distribution, the lognormal distribution is a type of distribution that is often used to describe breakdowns in varying situations (Maruddani, at el., 2021)
   a. Probability Density Function Lognormal
   $$F(t) = \frac{1}{\sqrt{2\pi\sigma}} \exp\left[-\frac{1}{s^2}\left(in\frac{t}{tmed}\right)^2\right] \quad (5)$$
   b. Reliability Function
   $$R(t) = 1 - F(t) \quad (6)$$
   c. Cumulative Distribution Function
   $$F(t) = \phi\left(\frac{\text{Int}-\mu}{\sigma}\right) \quad (7)$$
   d. Damage Rate Function
   $$H(t) = \frac{f(t)}{s(t)} \quad (8)$$
3. Ekponensial Distribution, Describes a machine breakdown that stops the machine due to damage to one of its components or equipment (Wicaksono, et al, 2021).
   a. Probability Density Function Exponensial
   $$F(t) = \lambda e^{-\lambda t} \quad (9)$$
   b. Reliability Function
   $$R(t) = e^{-\lambda t} \quad (10)$$
   c. Cumulative Distribution Ffunction
   $$F(t) = 1 - \exp(-\lambda t) \quad (11)$$
   d. Damage Rate Function
   $$H(t) = \frac{f(t)}{s(t)} \quad (12)$$
4. Weibull Distribution, This distribution is commonly used to analyze the loss of performance of a machine until it can no longer operate due to death or damage (Tamba, et al., 2023).
   a. Probability Density Function weibull
   $$F(t) = \frac{\beta}{\eta}\left(\frac{t}{\eta}\right)^{\beta-1} . e^{-\frac{t}{\eta}^{\beta}} \quad (13)$$
   b. Fungsi Keandalan
   $$S(t) = \exp\left(-\frac{t^y}{\theta}\right) \quad (14)$$
   c. Fungsi Distribusi Kumulatif
   $$F(t) = 1 - \exp\left(-\frac{t^y}{\theta}\right) \quad (15)$$
   d. Fungsi Laju Kerusakan
   $$H(t) = \frac{f(t)}{s(t)} = \frac{\beta}{\alpha}\left(\frac{t}{\alpha}\right)^{\beta-1} \quad (16)$$

Several previous studies have discussed the application of the Reliability Centered Maintenance (RCM) method on industrial equipment, such as on hoist crane machines (Kevin, 2025) and on excavator engine components (Nasution, 2023). However, these studies have not fully examined the specific case of Screw Press machine failure, especially by using actual damage data, maintenance time, and its impact on production achievement for a full year. In addition, previous studies tend to develop maintenance schedules without deeply integrating data on the frequency of damage to each component and specific downtime.

3. RESEARCH METHOD

The research methodology describes a series of stages that will be carried out, starting from the initial stage to the end of the research process. Each step in the methodology is designed to ensure that the research proceeds in a systematic and structured manner**.** Preliminary study is the initial stage in a research that aims to collect basic information and understanding of the topic to be researched based on real conditions in the field. In this study, preliminary studies were carried out with field observations, researchers conducted surveys directly in the field and conducted interviews with maintenance assistants.

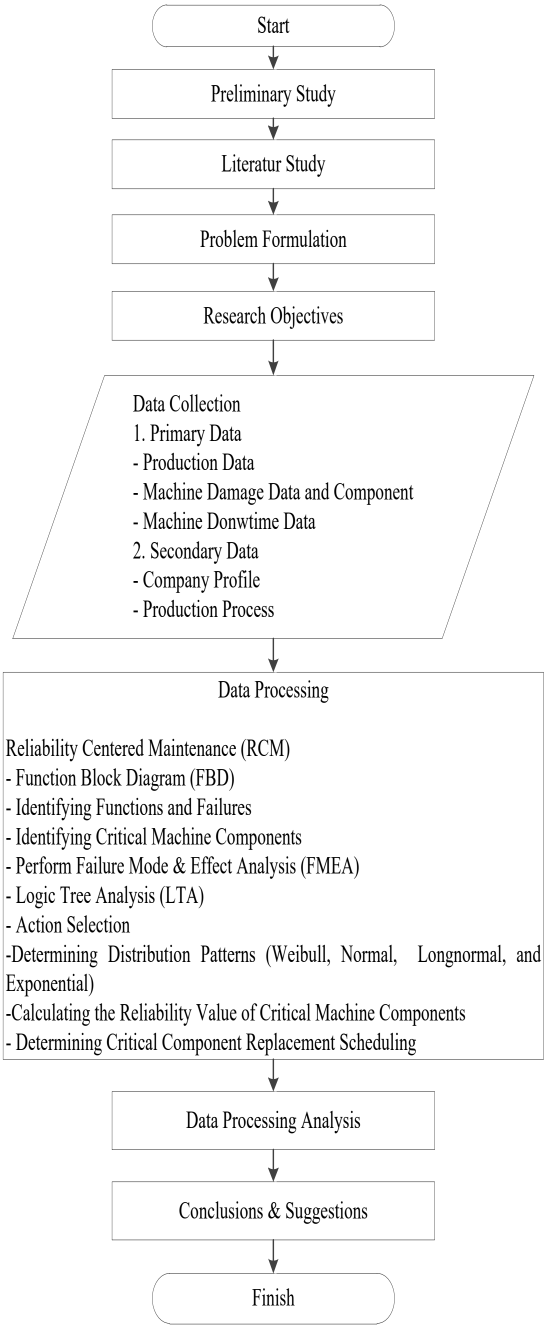

Figure 1. Flowchart of research methodology

The survey results showed that PT SIR implements a maintenance system with the corrective maintenance method, namely repairing and replacing production machine components when they are damaged. In addition, there is also planned maintenance carried out every two weeks to clean production machinery. The literature study was conducted to collect, analyze, and evaluate information from various written sources relevant to the topic or problem found at the location as the object of research. The data collection techniques used are primary data and secondary data. Primary data is the main data used for data processing purposes and is taken directly by researchers at the research location. The data collected includes production data, damage and component data, and machine downtime data. Secondary data is additional data that is complementary and not used in the main data processing process. Secondary data is not directly taken by researchers.

4. RESULT AND DISCUSSION

Some of the damage to the Screw Press machine during 2023 includes components such as worm screws that are worn or broken, shafts that are broken due to overload, bearings that break due to lack of lubrication, damage to the filter in the press cage. Here are some component data on the machine under study, namely the screw press machine. The following table presents the component damage on the screw press machine.

Table 2. Srew press component damage data

No	Component	Number of breakdowns (times)	Maintenance Time (hours)
1	Bearing	11	49,5
2	Spur Gear	5	27,5
3	Pinion Gear	3	18
4	Press Cage	6	30
5	Shaft Press	7	56
6	Expeller Arm	4	6
7	Short Arm	3	4,5
8	Long Arm	3	4,5
9	Worm Screw	12	108
	Total	**54**	**304**

Failure Mode and Effect Analysis (FMEA)

Failure Mode and Effect Analysis (FMEA) is used to identify, analyze, and prioritize potential failures in a process, system, or product, and their impact on performance and safety.

$$RPN = S \times O \times D \quad (17)$$

The FMEA analysis on the srew press machine at PT. SIR is as follows:

Table 3. FMEA srew press machine

No	Component	Function Component	Mode Failure	Effect Component Failure	S	Cause Failure	O	Action Taken	D	RPN
1	Bearing	Reduces friction between other components	Unstable engine speed	-Excessive vibration - Cracks/wear	8	-Lack of lubrication -Overload -Improper installation	7	-Regular replacement -Regular lubrication	9	504
2	Spur Gear	Connecting circular motion from one shaft to another	Drive failure, power loss	Broken or worn teeth	7	-Overload -Lack Of lubrication	6	-Change of gear teeth -Periodic check -Lubrication treatment	7	294
3	Pinion Gear	Connecting and transferring rotational motion between components	Worn or damaged teeth	Machine drive failure, high vibration	7	-Lack of lubrication -overload	4	-Inspection -Periodic gear replacement	5	140
4	Press Cage	Filtering and as a filter for processed materials	The filtration process is hindered	The surface of the mesh-net is thinned	8	-Press cage meshes clogged due to foreign parts entering -corrosion	6	-periodic checks -regular cleaning	8	384
5	Shaft Press	Connecting and transferring rotational motion between components.	Engine rotation stops and is not smooth	-Excessive vibration -Breakage -Decrease in engine performance	8	-Lack of oil lubrication -Unbalanced load received	7	-Periodic inspection -Regular lubrication	8	448
6	Expeller Arm	Squeezing loose palm fruits to produce oil	Loss of thrust due to hydraulic leakage	Interference during pressing	7	-Overload -Foreign objects entering the machine	4	-Periodic inspection -Provide Sufficient Lubrication	4	112
7	Short Arm	Connects or drives other components	Damage or breakage of the arm	Interference during pressing	6	-Overload - Improper installation position	3	-Periodic inspection - provide sufficient lubrication	5	90
8	Long Arm	Connects or drives other components	Damage or breakage of the arm	Interference during pressing	6	-Overload - Improper installation position	3	-Periodic inspection -Provide sufficient lubrication	5	90
9	Worm Srew	Pressing palm fruits and separating pulp and oil	Extraction process halted	-Damage To The worm thread -Worm Teeth wear	8	-Excessive Friction -Poor lubrication -Foreign material ingress	7	- Replacement of worms according to age -Regular checking	8	448

Table 4. Recapitulation of RPN value of srew press machine

No	Broken Component	S	O	D	RPN Value	Ranking
1	Bearing	8	7	9	504	1
2	Spur Gear	7	6	7	294	5
3	Pinion Gear	7	4	5	140	6
4	Press Cage	8	6	8	384	4
5	Shaft Press	8	7	8	448	2
6	Expeller Arm	7	4	4	112	7
7	Short Arm	6	3	5	90	8
8	Long Arm	6	3	5	90	9
9	Worm Screw	8	7	8	448	3

The table above explains that there are 5 critical components of the srew press machine, namely bearings, press cage, press shaft, worm screw and spur gear. The RPN value produced by the component also has the greatest value of the other components. From the results of the RPN value obtained using FMEA analysis, the results can be described in the form of percent (%), namely the equation as follows:

$$\text{Percentage (\%) RPN} = \frac{\text{RPN Value}}{\text{Total RPN Value}} \times 100\% \quad (18)$$

Cumulative percent = previous % RPN + next % RPN (19)

Table 5. Frequency of damage types of srew press machine components

No	Damaged Compon	RPN Value	Percentage%	Cumulative Percentage %
1	Bearing	504	20%	20%
2	Spur Gear	448	18%	38%
3	Pinion Gear	448	18%	56%
4	Press Cage	384	15%	71%
5	Shaft Press	294	12%	83%
6	Expeller Arm	140	6%	88%
7	Short Arm	112	4%	93%
8	Long Arm	90	4%	96%
9	Worm Screw	90	4%	100%
	Total	**2510**	**100%**	-

From Table 5 frequency of damage types above, a pareto diagram can be made in the Figure 2.

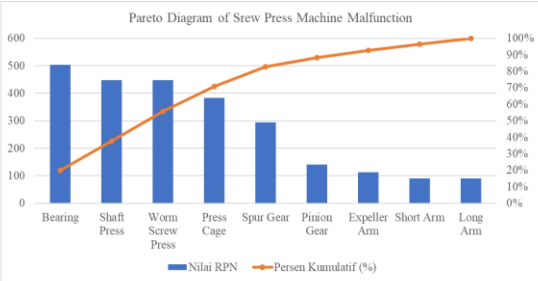

Figure 2. Pareto diagram of srew press machine malfunction

Based on the Pareto Diagram in Figure 2, it is known that the concept of the pareto diagram is 80:20. Component damage included in 80% is Bearing, Shaft Press, Worm Srew, and Press Cage and Spur Gear.

Logic Logic Tree Analysis (LTA)

Logic Tree Analysis (LTA) aims to classify the failure modes of each component by category. The following classification of failure modes is divided into 4 categories: (1) Category A (Failure mode impacting safety), (2) Category B (Failure mode affects production), (3) Category C (Failure mode impacting non-production), (4) Category D (Hidden failure mode).

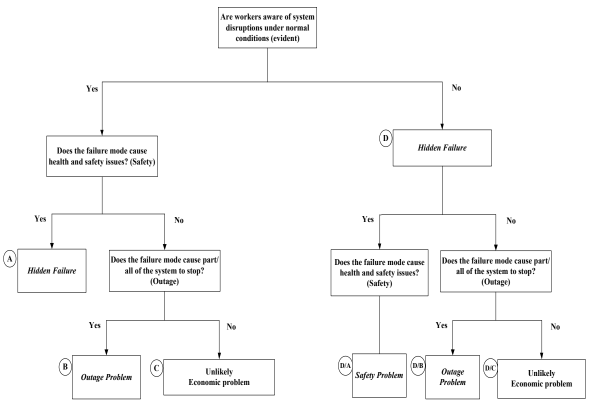

Figure 3. Structure Logic Tree Analysis (LTA)

The Logic Tree Analysis (LTA) of the Screw Press Machine is as follows:

Table 6. Logic tree analysis (LTA) srew press machine

No	Component	Evident	Safety	Outage	Category
1	Bearing	Y	N	Y	B
2	Shaft Press	Y	N	Y	B
3	Worm Screw	Y	N	Y	B
4	Press Cage	Y	N	Y	B
5	Spur Gear	Y	N	Y	B

From the results of the Logic Tree Analysis (LTA) of the Srew Press machine in table 5. which is included in category B (Outage), namely the Bearing, Shaft Press, Worm Srew component, and Press Cage and Spur Gear. This component is included in category B because the failure mode can shut down the machine system.

Task Selection

Action selection is the final step in the RCM process. Action selection. Classifying the types of damage that occur on the Srew Press machine into the appropriate preventive action categories is the basis for action selection. Here is how to determine the selection of appropriate actions to address malfunctions and damage to each critical component of the Srew Press machine (Figure 4).

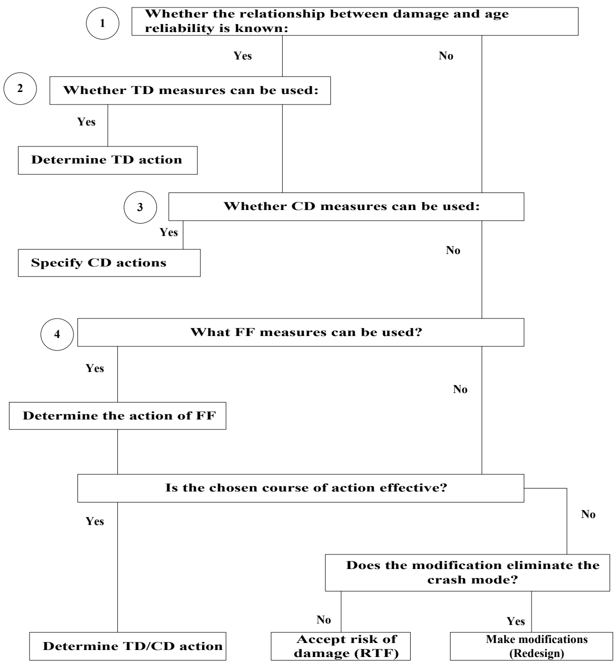

Figure 4. Task selection structure

The following is a recapitulation of the types of damage that occur to each critical component of the srew press machine based on category and action selection:

Table 7. Recapitulation of srew press machine maintenance action selection

No	Part	Failure Mode	Selection Task
1	Bearing	Broken or worn	T.D
2	Shaft Press	Broken	T.D
3	Worm Screw	Worm gear wear	T.D
4	Press Cage	Surface thinning	T.D
5	Spur Gear	Gear teeth worn/damaged	T.D

The selection of actions on bearing, shat press, worm screw, press cage, and spur gear components is TD (Time Directed). Actions that aim to focus more on replacement activities that are carried out periodically when damage or failure occurs.

Reliablity

Based on the results of the RCM analysis, thenthe reliability calculation is carried out on components included in the selection of Time Directed (TD) actions. These components include bearing, shat press, worm screw, press cage, and spur gear. To determine distribution that is suitable for damage, then the calculation of Time to repaire (TTR) And Time To Failure (TTF) of each component. These distribution identifications include Exponential distribution, Normal distribution, Lognormal distribution and Weibull. To find out the distribution pattern that matches the damage data of the Bearing Component can be seen in the probability density function (PDF) image below (Figure 5).

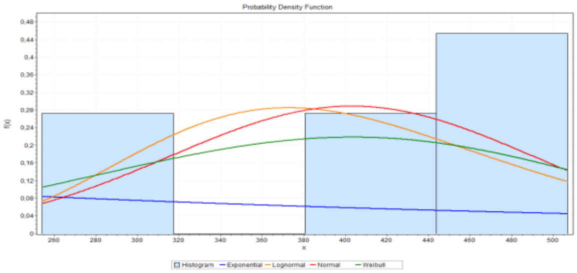

Figure 5. Probability density function (PDF) of bearing components

Figure 5. can be used to determine the appropriate distribution pattern with the data, To see the appropriate distribution, you can use the information from the text output which can be seen in the Table 8.

Table 8. Output parameter TTF bearing component

No	Distribusi	Statistic	Parameter
1	Eksponential	0,46775	λ =0,00248
2	Lognormal	0,26064	σ=0,23135 μ=5,9741
3	Normal	0,22681	σ=87,451 μ=403
4	Weibull	0,23079	α= 3,9344 β=434,64

Based on Table 8. statistical value Kolmogorof Smirnov statistical value of the distribution that value of the smallest Kolmogrov Smirnov statistics smallest in the type of damage distribution bearing is a Normal distribution with Kolmonogorov Smirnov statistic with a value of 0,22681, So that the damage interval data on B Bearing damage follows Normal distribution pattern. Parameter determination is based on the data distribution pattern obtained in the previous data distribution pattern determination step. Determination of parameters for each critical component using Easyfit 5.6 Professional Software. The following is a recapitulation table of the distribution pattern and its parameters.

Table 9. Recapitulation of TFF distribution and parameter test

No	Component	Distribution Pattern	Parameter
1	Bearing	Normal	σ=87,451 μ = 403
2	Shaft Press	Lognormal	σ=0,26459 μ =6,4411
3	Worm Srew Press	Normal	σ=113,78 μ = 365,58
4	Press Cage	Normal	σ= 07,46 μ = 737,5
5	Spur Gear	Normal	σ=197,08 μ = 671,2

Determination of Mean Time To Failure (MMTF)

Mean Time To Failure (MMTF) is the average time a machine component experiences failure or damage and must replace new components to operate as before. The following is the Mean Time To Failure (MMTF) value of the Srew Press machine component through the output calculations of the Easyfit 5.6 Professional software.

1. Normal Distribution, The components selected for Normal distribution are bearings, wom srew press, press cage, and spur gear. Therefore for the Mean Time To Failure (MMTF) value = parameter μ
2. Lognormal Distribution
   The selected Lognormal distribution component is the shaft press. The calculation in determining the Mean Time To Failure (MMTF) of the shaft press component is:
   a. *Shaft Press*

$$t_{med} = e^{\mu}$$
$$= 2{,}7182^{6{,}4411}$$
$$= 626{,}974$$

$$MTTF = t_{med} \times e^{\frac{\sigma^2}{2}}$$
$$= 626{,}974 \times 2{,}7182^{0{,}0350}$$
$$= 626{,}974 \times 1{,}0356$$
$$= 649{,}29$$

Table 10. Recapitulation of average time of breakdown of srew press machine components

No	Component	MTTF (hour)	Distribution
1	Bearing	403	Normal
2	Shaft Press	649,29	Lognormal
3	Worm Srew Press	365,58	Normal
4	Press Cage	737,5	Normal
5	Spur Gear	671,2	Normal

Calculation of Replacement Time Interval of Srew Press Machine Components

The calculation of the time interval for replacing Srew Press machine components aims to determine the optimal age at which preventive measures, such as replacing machine components, need to be taken in order to reduce the possibility of sudden damage that can hinder the smooth production process. The following is the calculation of the time interval for replacing critical components on the srew press, namely:

1. **Bearing Component Damage (Normal Distribution)**

$\sigma = 87{,}451$ $\mu = 403$ MTTF = 403

$$F(tp) = \phi\left(\frac{t-\mu}{\sigma}\right)$$

$$F(300) = \phi\left(\frac{300-403}{87{,}451}\right) = 0{,}1401$$

$$R(tp) = 1 - \phi\left(\frac{t-\mu}{\sigma}\right) = 1 - 0{,}1401 = 0{,}8599$$

$$M(tp) = \frac{MTTF}{F(tp)} = \frac{403}{0{,}1401} = 2876{,}517$$

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

$$= \frac{3x0{,}8599+3[1-0{,}8599]}{(300+3)x0{,}8599+[(2876{,}517+3)(1-0{,}8599)]} = 0{,}0045183$$

Table 11. Determination of bearing component replacement time interval

Tp	R(tp)	F(tp)	M(tp)	D(tp)	A(tp)
300	0,8599	0,1401	2876,517	0,0045183	0,995482
310	0,8554	0,1446	2786,999	0,0044698	0,99553
320	0,8289	0,1711	2355,348	0,0044693	0,995531
330	0,7967	0,2033	1982,292	0,0044849	0,995515
340	0,7257	0,2743	1469,194	0,004596	0,995404
350	0,7123	0,2877	1400,765	0,004578	0,995422
360	0,6985	0,3015	1336,65	0,004563	0,995437
370	0,6844	0,3156	1276,933	0,0045508	0,995449
380	0,6700	0,3300	1221,212	0,0045413	0,995459
390	0,6554	0,3446	1169,472	0,0045344	0,995466
400	0,6406	0,3594	1121,313	0,0045301	0,99547
410	0,6255	0,3745	1076,101	0,0045286	0,995471
420	0,6103	0,3897	1034,129	0,0045295	0,995471
430	0,5948	0,4052	994,571	0,0045333	0,995467
440	0,5793	0,4207	957,9273	0,0045393	0,995461
450	0,5636	0,4364	923,4647	0,0045481	0,995452
460	0,5478	0,4522	891,1986	0,0045594	0,995441
470	0,5319	0,4681	860,9272	0,0045732	0,995427
480	0,5160	0,4840	832,6446	0,0045894	0,995411

Based on Table 11 to determine the optimal age of replacement of Bearing components by looking at the smallest D (tp) value, from the results of the above calculations the smallest D (tp) value is 0.0044693. For the Tp value or time for maintenance of Bearing components, it is 320 hours with engine reliability of 82.89%. It can be concluded that after 320 hours of Bearing components operating, it is necessary to carry out maintenance and replacement of new components/parts. From the results of the calculation of the time interval for maintenance and replacement and prevention of failure of critical components of the srew press machine, it can be described in the table below:

Table 12. Recapitulation of proposed interval of critical component maintenance schedule

No	Component	MTTF (Hour)	Proposed Time Maintenance (Hour)	Distributon
1	Bearing	403	320	Normal
2	Shaft Press	649,29	470	Lognormal
3	Worm Srew Press	365,58	285	Normal
4	Press Cage	737,5	570	Normal
5	Spur Gear	671,2	520	Normal

Actions taken in the form of direct prevention of the source of damage to components based on time or component life. Maintenance of components is carried out by performing the following actions (Table 13).

Table 13. Proposal for failure prevention of srew press machine

No	Component	Proposal Prevention
1	Bearing	Replace parts according to service life and lubricate regularly.
2	Shaft Press	Replace worn components before they cause further damage. This includes bearings, seals, and gears.
3	Worm Srew Press	Periodically check and replace components when the srew serrations have begun to wear in accordance with the age and service time of the components.
4	Press Cage	Periodically check and clean the nets so that they do not clog when the machine is operating.
5	Spur Gear	Check periodically and ensure regular lubrication to prevent wear and failure.

The uniqueness of this research lies in the use of statistical approaches and software to quantitatively determine optimal maintenance intervals, thus providing a more applicable practical contribution in improving machine reliability and reducing downtime in the palm oil processing sector. This research may be affected by limited resources, in terms of time, energy, and cost, which may affect the depth of analysis and data collection. By recognizing these limitations, researchers can provide recommendations for further research and improve the methodology used.

5. CONCLUSION

The conclusions of this research are as follows: Develop a proposed maintenance schedule for each critical component on the Screw Press machine. In the bearing component, the selected distribution is normal distribution, with a proposed maintenance schedule of 403 hours. For the shaft press component, the selected distribution is lognormal distribution, with a proposed maintenance schedule of 470 hours. For worm screw components, the selected distribution is normal distribution, with a proposed maintenance schedule of 285 hours. For the press cage component, the selected distribution is normal distribution, with a proposed maintenance schedule of 570 hours. then the last for the spur gear component, the selected distribution is normal distribution, with a proposed maintenance schedule of 520 hours.
This research shows an increased effectiveness in the application of Reliability Centered Maintenance (RCM) compared to previous studies, which focused more on reducing preventive maintenance without a systematic approach. In contrast to previous studies that tend to be theoretical, this research proposes a more structured and efficient maintenance plan, taking into account safety and environmental factors as part of plant and equipment maintenance optimization. The results obtained also confirm that the updated RCM approach is better able to reduce equipment failures and improve overall system availability. Suggestions for future research include several important aspects that can improve the quality and depth of analysis, namely the use of diverse analytical methods in order to provide a more holistic perspective on machine maintenance.

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