ISSN:
E-ISSN:

Proceeding Universitas Muhammadiyah Gresik Social Science and Humanities Internasional Conference (UMGCINMATIC)

MAINTENANCE STRATEGY FOR ROTARY BRIQUETTE MACHINES AT PT. ARKATAMA INDONESIA USING FMEA METHOD

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ABSTRACT

This internship report focuses on studying the maintenance approach for rotary sieve machines at PT. Arkatama Indonesia, a company that makes coconut briquettes with a monthly production capacity of 100 tons. This topic is important because it helps make machines more reliable and improves product quality by using a more forward-thinking method. The methods used are Failure Mode and Effect Analysis (FMEA) to assess the risk of damage using the RPN value, and Reliability Centered Maintenance (RCM) with calculations for failure rate (λ) and system reliability. The results show that the Shaft Mount has the highest RPN value and the lowest reliability rate (4.95%), so it needs a Predictive Maintenance method. The Rotary Screen has a reliability level of 13.42%, and the Vanbelt Motor has 36.99%, which means they are suitable for Preventive and Corrective Maintenance. Using FMEA was very effective in making the operations run more smoothly, lowering machine downtime, and helping the company move towards Industry 4.0 at PT. Arkatama Indonesia.

Keywords: Maintenance Strategy, FMEA, MTBF, Rotary Screen.

1. INTRODUCTION

Briquettes are a renewable fuel source. Currently, briquette raw materials vary widely, including coal, coconut shells, tea waste, wood dust, and others. In their production, briquettes undergo multiple processing stages to achieve high-quality output. However, product quality can sometimes decline due to inadequate production equipment or suboptimal manufacturing processes.Incomplete mixing often results in briquettes that are not sufficiently compact and may crack or break during combustion. The homogeneity and composition of the mixture are among the most critical parameters determining the quality of charcoal briquettes. Therefore, an efficient mixer is required to maximize mixing performance and ensure consistent briquette quality. The aim of this research is to improve the mixing process and increase the batch volume of coconut shell briquette dough to enhance overall production output (Purwanto et al., 2019).According to Iskandar et al. (2019), coconut shell charcoal briquettes offer several advantages over conventional solid fuels, including high heat output, non-toxicity, smokeless combustion, longer burning time (sustained ember glow), potential as a coal substitute, and greater environmental friendliness.

The following is the briquette production process at PT. Arkatama Indonesia, located in Pekalongan, Central Java:

1. Preparation: Selecting high-quality coconut shell charcoal and labeling it according to its source.
2. Shifting: Manually sorting the coconut shell charcoal to remove unwanted waste components.
3. Screening: The sorted coconut shell charcoal is passed through a rotary screen machine to separate the desired material and remove excess ash.
4. Crushing: The screened charcoal is ground into a fine powder.
5. Mixing & Blending: The powdered charcoal is mixed with other binding agents and blended thoroughly until a smooth, homogeneous paste is achieved.
6. Molding: The blended mixture is fed into a briquetting machine, where it is compressed and cut into individual briquettes of the desired shape.
7. Drying: The formed briquettes are dried in an industrial oven until they reach the target moisture content.
8. QC/QA: Quality Control and Quality Assurance procedures are carried out to ensure each briquette meets established quality standards.
9. Packing: The finished coconut shell charcoal briquettes are packaged according to customer requirements.

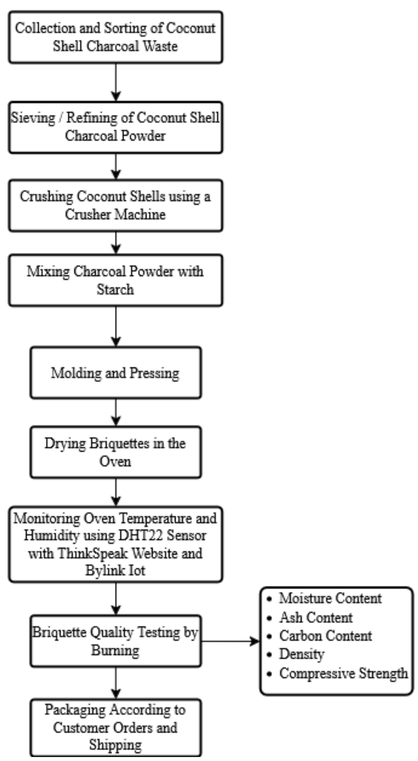

Figure 1. 1 Production Flow at PT. Arkatama Indonesia

Screening or sieving is a mechanical separation process based on differences in particle size. Screening is typically used on an industrial scale, whereas sieving is applied in laboratory-scale operations (Fanzuri et al., 2023).
According to Rizki (2020), the objectives of the screening process are as follows:

a. To prepare feed particles with the appropriate diameter for subsequent processing stages.
b. To minimize the inclusion of unwanted particles—either oversize material in primary crushing or undersize material in downstream processing—so that material can be efficiently recirculated to the next stage (e.g., secondary crushing).
c. To refine the final particle product to meet desired specifications.
d. To reduce the presence of undersize particles in the screened fraction.

According to Abdillah (2019), several factors influence the screening process:

a. Screening duration (optimal time): Excessive screening time may cause particle degradation, allowing particles that should not pass through the sieve to become fine enough to be screened. Conversely, insufficient screening time results in incomplete separation.
b. Sample mass: An overly large sample volume makes screening difficult due to particle congestion, whereas a smaller sample allows particles to move more freely and pass through the sieve more easily.
c. Vibration intensity: Higher vibration intensity increases particle-particle collisions, leading to particle abrasion and unintended size reduction. Consequently, particles may not be accurately separated according to the target size. Therefore, an optimal screening process requires moderate vibration intensity—sufficient to facilitate particle movement but not so high as to cause excessive collisions and particle wear—ensuring accurate separation based on the desired particle size.

Maintenance is a critical component of production systems and the product life cycle. Effective maintenance reduces unplanned production downtime, enhances long-term productivity, and preserves the functional performance of equipment. Thus, well-executed maintenance ensures smooth production operations with minimal errors or disruptions caused by potential failures during processing. Maintenance is defined as any activity performed to restore a system to its original operating condition in the shortest possible time (Hisyam et al., 2025). In general, there are two main types of maintenance: Planned Maintenance and Unplanned Maintenance.

2. METHOD

This study is a descriptive research that employs Reliability Centered Maintenance (RCM) as its research methodology. The data collected consist of primary data, specifically including records of production machine failures at PT. Arkatama Indonesia, as well as the time intervals between failures of the rotary-type coconut shell screening machine particularly focusing on the shaft support component. The main objective of this research is to determine and recommend an appropriate maintenance strategy for the rotary-type coconut shell screening machine at PT. Arkatama Indonesia.To facilitate data processing, this study utilizes a flowchart to clearly illustrate and streamline the analytical procedure. The following figure presents the flowchart used in this research.

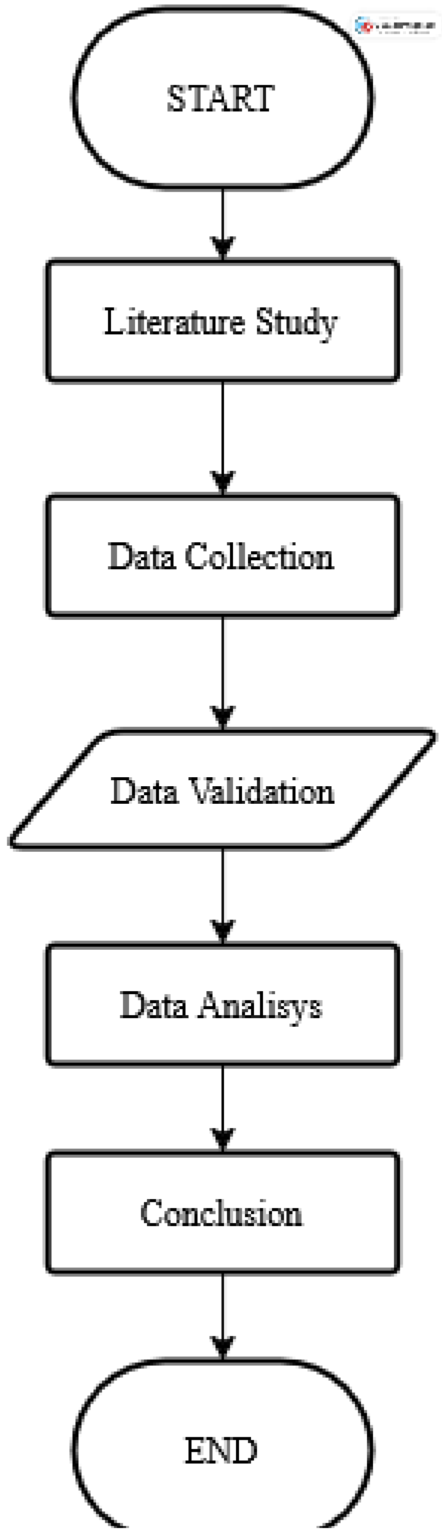

Figure 2. 1 Research flow diagram

2.1 Specifications of the Rotary Screening Machine at PT. Arkatama Indonesia

Tabel 2. 1 Spesification rotary screening machine

Spesification rotary screening machine	
Machine Type Rotary	
Stationary rational speed	10-20 Rpm
Power	3Hp
Phase	3 / 380 V
Frequency	50Hz
Dimension (LxWxH)	2000 x 4000 x 1500 mm
Maximum screen lenght	4000mm
Screen diameter	1200 mm
Shaft lenght	4000 mm
Gear Box (Speed reducer)	80 inc
Mesh size	3½ mm
Control panel	On/Off

The rotary screening machine is used to process coconut shell charcoal, with a daily production target of approximately 4–5 tons. To prevent severe breakdowns that could disrupt production flow, a regular inspection and maintenance schedule is essential for this equipment.

Figure 2. 2 Rotary screening machine

The machine is operated by a team of four personnel:One operator feeds the raw material into the hopper,One prepares the material to be screened,One collects and weighs the fine charcoal powder from the output,The fourth handles the coarse fraction from the hopper outlet and transfers it to the hammer mill for further size reduction.This operational setup supports the machine's capacity of 4–5 tons everyday.

2.2 Failure Mode and Effects Analysis (FMEA)

FMEA is a systematic process used to identify and analyze potential failure modes in a product or system. The insights gained from this analysis help assess the impact of each failure on overall performance, thereby guiding design or process improvements. Three key risk factors are evaluated for each potential failure mode:

- Severity (S): the seriousness of the consequences if the failure occurs,
- Occurrence (O): the likelihood or probability of the failure occurring,
- Detection (D): the likelihood that the failure will go undetected before reaching the customer or causing a breakdown.

These three factors Severity, Occurrence, and Detectability are multiplied to calculate the Risk Priority Number (RPN) using the formula:RPN = S × O × D (Wicaksono & Rosady, 2024).
The RPN serves as a quantitative indicator to prioritize maintenance actions, with higher values indicating more critical failure modes requiring immediate attention.

Tabel 2. 2 Severity (S)

Level	Effect	Criteria
10	Extremely hazard	Component failure suddenly endangers work safety
9	Hazard	Component failure endangers work safety with prior warning
8	Verry high	Downtime more then 5 hari
7	High	Downtime more then 2 hari
6	Moderatly high	Downtime more then 8 jam
5	Medium	Downtime more then 4 jam
4	Low	Downtime more then 2 jam
3	Minor	Downtime more then 1 jam
2	Verry minor	Downtime up to 1 jam
1	None	No effect

Tabel 2. 3 Occurance (O)

Level	Probabilty of occurence
10	More than 50% per year of use
9	25–50% per year of use
8	25–50% per year of use
7	5–14% per year of use
6	Less than 5% per year of use
5	Once per year of use
4	Once every 2–3 years of use
3	Once every 4–5 years of use
2	About 3 times per year of use
1	Never occurs

Tabel 2. 4 Detection (D)

Level	Detection control
1	Certainly detected
2	Very highly detectable
3	Highly detectable
4	Fairly highly detectable
5	Moderately detectable
6	Low detectability
7	Very low detectability
8	Difficult to detect
9	Very difficult to detect
10	Not detectable

After the total RPN (Risk Priority Number) score and risk level are determined, the next step is to define the maintenance program criteria based on the total RPN value (Puthillath & Sasikumar, 2015), as shown in Table 2.5 below.

Tabel 2. 5 Maintenance strategy criteria

Maintenance strategy	
Predictive Maintenance	RPN > 300
Preventife Maintenance	200 < RPN < 300
Corrective Maintenance	RPN < 300

2.3 Reability

Reliability is the probability that a component or system will perform the required function under specified operating conditions for a given period of time. Reliability refers to the likelihood of repeated failures (Ebeling, 1997).

An equipment can be defined in two states: good and failed. Thus, when reliability equals 1, the system is certainly in good condition, and when reliability equals 0, the system is certainly in a failed condition.The reliability factor can be expressed in several forms:

- As a percentage (e.g., 95%)
- As a probability (e.g., 0.95)
- As a ratio or statistical value, such as MTBF (Mean Time Between Failures), failure rate, and others.

The reliability function $R(t)$can be expressed as follows:

$$R\ (t) = \int_{t}^{\infty} \frac{1}{\theta} e^{\frac{-u}{\theta}} du = e^{-t/\theta} \qquad (2.3)$$

Where:

- e = base of the natural logarithm
- θ = mean life (average lifetime of the equipment)

The mean life (θ) refers to the average operating life of an equipment, which is equivalent to MTBF (Mean Time Between Failures). The inverse of MTBF is known as the instantaneous failure rate (λ).

Thus, the relationship can be expressed as:

$$R\ (t) = e^{-t/MTBF} = e^{-\lambda t} \qquad (2.4)$$

2.4 Failure Rate and MTBF

Failure rate and MTBF are the most commonly used parameters in reliability calculations. The failure rate (λ) refers to the frequency of failures or the rate at which failures occur over a specific time period.

It can be expressed as:

- Number of failures per hour
- Number of failures per million hours
- Percentage of failures per 1000 hours

The failure rate (λ) can be calculated using the following formula:

$$\boldsymbol{\lambda} = \frac{\boldsymbol{Number\ of\ failure}}{\boldsymbol{Total\ operation\ hours}} \tag{2.5}$$

3. RESULT AND DISCUSSION

Maintenance on Rotary / Revolving Screen MachineThe maintenance activities on the rotary or revolving screen machine are divided into two types: Planned Maintenance and Unplanned (Emergency) Maintenance.

Planned maintenance activities that are commonly carried out on the rotary screen machine include:

- Performing greasing on the pillow block.
- Inspecting the motor and gearbox before and after operation.
- Checking the screening mesh.

Unplanned (Emergency) maintenance commonly occurs in the form of replacement of the screen support on the rotary sieving machine.This is because the supports on the rotary machine can break at any time, often due to overloading when the material load exceeds the machine's designed capacity.The results of the Risk Priority Number (RPN) calculation can be seen in Table 3.

Tabel 3. 1 Result of risk priority number (RPN) calculation

No	Component	Failure effect	S	Failure cause	O	D	RPN
1	Shaft Support	Welding cracks and downtime for repair ± 4 hours	9	Supporting an excessive load because the support is positioned at the end	8	4	288
2	Rotary Screen Mesh	During coconut shell sieving, mixed impurities/metal cause damage; downtime for repair > 4 hours	5	The mesh holes often break due to the presence of dirt and metal particles	10	4	200
3	Motor V-belt	Belt slips and loosens due to component misalignment; downtime for repair ± 1 hour	3	Machine vibration causes misalignment between gearbox and motor	5	2	30
4	Rotary shaft	Machine cannot operate; downtime for repair ± 5 hours	5	Operator moves the lever too forcefully / vibration from workpiece affects spindle	2	2	24

The results of the RPN calculation show that the shaft support component has an RPN value of 288, which is the highest value among all components. This indicates that the failure of this component has the highest priority level for corrective actions and maintenance programs.The determination of the critical components of the rotary-type coconut shell charcoal screening machine was carried out using the Failure Mode and Effects Analysis (FMEA) method.This analysis aims to identify the priority level for maintenance and repair activities. Each component has different failure modes and failure effects, which influence the level of risk and the type of maintenance strategy required.

Tabel 3. 2 Failure mode effect analisys (FMEA)

Item/ proses function	Potensial failure mode	Potensial cause mechanism failure	Current Control & Prevention Process	Recommended Action	Responsibility & Target Completion Date	Action Taken				
						Action Taken	Sev	Occ	Det	RPN
Shaft Support	Welding crack	Insufficient weld penetration and weak material support for the shaft bracket	Select stronger material for shaft bracket and adjust shaft diameter	Perform preventive maintenance	Downtime for repair approximately 4 hours	Prepare stock of shaft support components	9	8	4	**288**
Rotary Screen Mesh	Tearing	Presence of stones or metal mixed with coconut shell material	Inspect materials before feeding into rotary machine	Perfom preventive Maintenance	Downtime for repair approximately 4 hours	Prepare stock of rotary screen mesh	5	7	6	**210**
Motor V-belt	Slipping and loosening	Machine vibration causes misalignment between gearbox and motor	Check oil and grease condition on gearbox and motor shaft	Perfom corrective Maintenance	Downtime for repair approximately 1 hours	Adjust distance between gearbox and motor, then tighten	3	5	2	**30**

Based on the FMEA results:

- The shaft support has the highest RPN (288), indicating it is the most critical component and requires priority preventive maintenance and material improvement.
- The rotary screen mesh has a moderate RPN (210), suggesting it should be regularly inspected and maintained.
- The motor V-belt has a low RPN (30), meaning that corrective maintenance is sufficient when failure occurs.

3.1 Mean Time Between Failure (MTBF)

MTBF is a fundamental indicator of reliability. It represents the average time a system operates without experiencing failure during a specific period of operation. The higher the MTBF value, the more reliable the system is considered to be. In other words, a longer MTBF indicates that the equipment or component can function effectively for a longer time before a failure occurs(Hesthi, Ningtyas, Jufriyanto, et al., 2023) .

Tabel 3. 3 Reability factor / System reability improvement

Components	**Causes**	**Assumed Number of Failures per Month**
Shaft Support	Insufficient weld penetration and weak support material	3 failure / month
Rotary screen	Presence of stones or metal mixed with coconut shell material	2 failure / month
Motor V-belt	Shift in distance between motor and gearbox	1 failure/ month

Tabel 3. 4 Failure rate and MTBF

Components	**λ (Per hours)**	**MTBF (JAM)**
Shaft support	0.0139	$\frac{1}{0.0139} \approx 71.94$ jam
Rotary screen	0.0093	$\frac{1}{0.0093} \approx 107.53$ jam
Motor V-belt	0.0046	$\frac{1}{0.0046} \approx 217.39$ jam

Tabel 3. 5 Failure rate calculation

Components	**Equation**
Shaft support	0,0139 X 216=3.0024
Rotary screen	0,0093 X 216=2.0088
Motor V-belt	0,0046 X 216=0.9936

Tabel 3. 6 Calculation reability for 216 hours

Components	***Reability formula (Rt)* = (216)**	**Reability (%)**
Shaft support	$e^{-0.01389 \times 216} = 3.0024 \approx 0.0495$	4,95 %
Rotary screen	$e^{-0.00926 \times 216} = 2.0088 \approx 0.1342$	13,42 %
Motor V-belt	$e^{-0.0046 \times 216} = 0.9936 \approx 0{,}3699$	36,99 %

Based on the calculations of MTBF and reliability (R) for 216 hours of operation:

- The motor V-belt has the highest MTBF (217.39 hours) and the highest reliability (37.02%), indicating that this component is the most reliable and stable, with fewer failures over time.
- The shaft support has the lowest MTBF (71.94 hours) and the lowest reliability (4.97%), meaning it is the least reliable component and the most prone to failure.
- The rotary screen mesh lies in between, with moderate reliability (13.41%) and MTBF of 107.53 hours.

According to the FMEA analysis, failures are mainly caused by : external factors, such as the presence of stones or metal mixed in the raw coconut shell material, and design factors, such as insufficient welding penetration and inadequate material strength.components with high RPN values should be prioritized for Predictive, Preventive, or Corrective Maintenance programs to improve system reliability and reduce downtime (Hesthi, Ningtyas, Pahlawan, et al., 2023).

Figure 3. 1 Condition of the broken shaft support before replacement

The shaft support failure occurred as a result of inadequate weld penetration and insufficient material strength to sustain heavy loads. It is recommended to replace the shaft with a material having a diameter of 25 mm and a length of 350 mm. The additional weight of the new shaft will not significantly affect the motor's rotational speed (RPM).

Figure 3. 2 The condition after the replacement of the shaft support component.

Following the replacement of the rotary screen shaft component, the machine has continued to operate smoothly with no further problems occurring on the shaft support. Figure 3.1 illustrates the condition after the shaft support component replacement.

4. CONCLUSION

Based on the previous chapters, the author of this internship report concludes that the study focuses on the maintenance strategy for the rotary-type screening machine used in the charcoal briquette production process at PT.Arkatama Indonesia. The main causes of failure include insufficient weld penetration on the shaft support, which reduces structural strength; the presence of stones or metal fragments in the raw material, which causes wear and damage to the screen; and misalignment between the motor and gearbox, which leads to belt slippage and additional load on the V-belt. The FMEA analysis shows that the shaft support has the highest RPN (Risk Priority Number), as its failure results in significant downtime and poses potential safety hazards for operators. The rotary screen and motor V-belt also have notable RPN values, although lower in comparison. Based on the RPN results, the recommended maintenance strategies are as follows: Predictive Maintenance for components with RPN > 300, Preventive Maintenance for RPN between 200–300, and Corrective Maintenance for RPN < 200. This study successfully identified the critical components of the rotary screen machine through FMEA analysis, quantitatively calculated the reliability and failure rate (λ), and highlighted areas for improvement in MTBF calculation. Furthermore, it proposes the development of an IoT-based monitoring system for the briquette oven to enhance quality control and operational efficiency. In conclusion, this report not only provides technical solutions but also serves as a foundation for developing a modern, sustainable, efficient, and safe maintenance system in the future.

Recommendations based on the results and analysis presented in this report, the following strategic recommendations are proposed to improve efficiency, reliability, and production quality at PT. Arkatama Indonesia:

1. Improve the Design and Material of Critical Components
   - Shaft Support: Use stronger materials (e.g., ASTM A36 or SS400 steel). Apply full-penetration welding and conduct periodic Non-Destructive Testing (NDT) inspections. Add additional brackets to reinforce the structure.
   - Rotary Screen: Install a magnetic separator at the material inlet to remove metal or stone contaminants. Use high-quality, wear-resistant mesh materials such as AISI 304 stainless steel.
   - Motor V-Belt: Install an alignment guide or adjustable motor base to facilitate tension adjustment. Use high-strength V-belts and perform regular tension inspections.
2. Implement an RPN-Based Maintenance Strategy (Reliability-Centered Maintenance – RCM)
   - Shaft Support (High RPN): Apply Predictive Maintenance using vibration sensors or thermal imaging to detect early failures. Conduct weekly vibration analysis to monitor performance
   - Rotary Screen & Motor V-Belt: Apply Preventive Maintenance by scheduling weekly greasing of pillow blocks, mesh inspection, and V-belt tension adjustment. Document all maintenance activities in a digital logbook.
   - Avoid Breakdown Maintenance, as it leads to increased downtime and higher operational costs.

3. Continuous Improvement and Collaboration

   Engage internship students to participate in ongoing maintenance analysis and improvement programs within the company. This initiative promotes sustainable maintenance practices and knowledge transfer between academia and industry.

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