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Screw Press Failure Risk Analysis Using FMEA at PT SISIRAU Pressing Station

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ABSTRACT
The screw press is a critical machine in crude palm oil (CPO) extraction, and its failure may reduce production efficiency and increase oil losses. This study identifies failure modes in screw press components, examines their causes and effects, and prioritizes preventive maintenance using Failure Mode and Effects Analysis (FMEA). Data were obtained from field observations, interviews with three personnel, and company records at the PT SISIRAU palm oil mill. Six components were assessed: the worm screw, press cage, bearing, hydraulic system, main shaft, and electric motor. The worm screw had the highest Risk Priority Number (RPN) of 196, followed by the press cage (168) and bearing (126). The principal contributing factors included heavy operating loads, continuous friction, inadequate lubrication, and foreign materials entering the pressing system. Recommended preventive measures include routine inspection, installation of a magnetic separator, scheduled lubrication, condition monitoring, and timely component replacement. These recommendations are intended to reduce failure risk and support reliable, continuous CPO production.

Keywords: *Failure Mode and Effects Analysis (FMEA), Risk Priority Number (RPN), Preventive Maintenance, Screw Press, Palm Oil*

1. Introduction

The palm oil industry is a strategic sector of the Indonesian economy. Its principal product, crude palm oil (CPO), has substantial economic value and is an important export commodity. In palm oil processing, the pressing station extracts oil from previously digested fruit. Screw press performance affects oil extraction efficiency, CPO quality, and the amount of oil lost during production (Nur & Isranuri, 2021).

Previous studies have examined screw press failures using Failure Mode and Effects Analysis (FMEA). Nur & Isranuri (2021) showed that FMEA can identify critical components associated with production disruptions through Risk Priority Number (RPN) scores. Syarifuddin & Andhini (2023) also concluded that FMEA helps companies prioritize maintenance actions for the highest-risk components. In addition, Maulana & Pandria (2023) reported that failures of key screw press components can reduce extraction efficiency and increase oil losses. Together, these studies indicate the value of FMEA in identifying failure risks and guiding maintenance strategies.

Building on this literature, the present study focuses on the failure modes of the main screw press components at the PT SISIRAU palm oil mill (PMKS PT SISIRAU). It examines failure modes and assesses their risks using severity, occurrence, and detection scores. Component-specific RPN values are then used to propose maintenance priorities for reducing production disruptions and the potential for oil losses.

Direct observations undertaken during practical industrial work at PMKS PT SISIRAU indicated recurring problems involving several screw press components, potentially affecting machine efficiency, production continuity, and oil losses. These conditions point to the need for a systematic assessment of failure risks to support better-targeted maintenance activities (Maulana & Pandria, 2023).

Accordingly, the study identifies the causes and effects of screw press component failures and uses FMEA to prioritize preventive measures through RPN scoring (Sarbeni & Saputra, 2023). The findings are intended to inform a preventive maintenance strategy

for improved machine reliability and support achievement of the mill's CPO production targets (Rofiq & Darmawan, 2022). Specifically, the objectives are to (1) identify component failure modes, (2) examine their causes and effects, and (3) prioritize corrective and preventive maintenance actions based on RPN values.

2. Methods

This study employed a descriptive quantitative approach based on Failure Mode and Effects Analysis (FMEA) to identify failure modes, examine their causes and consequences, and establish maintenance priorities for the screw press at PMKS PT SISIRAU (Iman et al., 2022). The investigation was conducted at the mill's pressing station in Aceh Tamiang Regency, Indonesia, focusing on components that affect the continuity of palm oil extraction.

Primary data were obtained by observing the operating condition of the screw press, documenting failures, and interviewing three mill personnel involved in machine operation and maintenance. These participants are described as a chief mechanic, a station operator, and a maintenance department staff member. Secondary data were derived from machine maintenance records, production reports, and company documents concerning the failure history of screw press components.

The procedure began by identifying components at risk of failure. For each component, the failure mode, likely causes, and potential effects were determined from observations and interviews (Lestari et al., 2021). Severity (S), Occurrence (O), and Detection (D) were then scored as the three principal FMEA parameters (Kristanto & Husyairi, 2022).

Severity represents the consequences of a component failure; Occurrence reflects how frequently a failure may arise; and Detection indicates the likelihood of detecting a failure before a more serious consequence occurs. Ratings were determined with reference to field conditions and discussions with experienced operators and maintenance personnel (Saputra & Santoso, 2021). The scoring guidance, on a scale of 1–10, is presented in Table 1.

Table 1. Rating Criteria for Severity, Occurrence, and Detection

Score	Severity (S) criterion	Occurrence (O) criterion	Detection (D) criterion
1	No resulting effect	>30,000–50,000 operating hours (>5 years)	Certain to be detected
2	Ineffective operation; workers are unaware	Every 30,000 operating hours (5 years)	Very likely to be detected (alarm available)
3	No impact; operator is aware	Every 20,000 operating hours (4 years)	Likely to be detected
4	Function changes; noticed by many workers	Every 10,000 operating hours (2 years)	Very likely to be identified
5	Reduced ease of use or functional comfort	Every 5,000 operating hours (1 year)	Moderate probability of detection
6	Abnormal or reduced equipment performance	Every 3,000 operating hours (4 months)	Low probability of detection
7	Reduced primary function	Every 1,000 operating hours (2 months)	Very unlikely to be detected
8	Loss of primary function	Every 500 operating hours (1 month)	Low detectability; difficult to identify
9	Loss of primary function with warning	Every 100 operating hours (1 week)	Extremely difficult to detect
10	Complete component failure without warning	Every 24 operating hours (1 day)	Not detected

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Source: Prosiding Konferensi Integrasi Interkoneksi Islam dan Sains (2022).

After the three ratings were obtained, the Risk Priority Number was calculated using Equation (1), which follows the basic FMEA approach (Kristanto & Husyairi, 2022).

$$\mathbf{RPN = S \times O \times D} \quad \mathbf{(1)}$$

Calculated RPN values were grouped into five risk categories to identify critical areas requiring attention, as described in Table 2 (Tutik et al., 2022).

Table 2. Risk Levels Based on RPN Values

Risk level	RPN range
Very high	>100
High	76–100
Moderate	51–75
Low	26–50
Very low	1–25

Higher RPN values indicate higher priorities for preventive actions under the risk classification used in the study. Components were ranked by RPN, and practical maintenance recommendations were then formulated to reduce failure risks, maintain machine reliability, and support the continuity of CPO production at PMKS PT SISIRAU.

The overall assessment sequence is summarized in Figure 1.

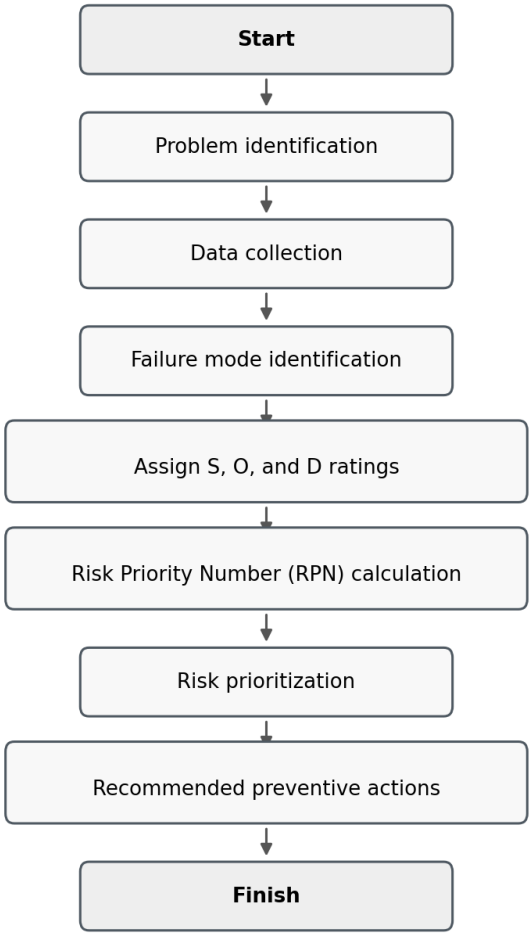


Figure 1. FMEA-Based Screw Press Failure Assessment Procedure at PMKS PT SISIRAU

3. Results and Discussion

3.1 Data Collection

Field observations, a literature review, and structured interviews with operating and maintenance personnel at PMKS PT SISIRAU over a two-week period provided information on screw press failure modes and their likely causes. The six components and identified failure modes are summarized in Table 3.

Table 3. Identified Screw Press Component Failures and Causes

No.	Component	Failure mode	Identified cause
1	Bearing	Fracture	End of the stated service life (10,000 hours), entry of metal fragments into the screw press, and insufficient routine lubrication.
2	Main shaft	Shaft fracture	Excessive load during operation and metal fragments entering the pressing unit from the digester.
3	Worm screw	Fracture	Excessive loading, continuous friction, and prolonged use.
4	Press cage	Wear	High operating loads and prolonged use, resulting in material wear.
5	Hydraulic system	Wear	Excessive pressure leading to progressive hydraulic component wear.

No.	Component	Failure mode	Identified cause
6	Electric motor	Burnout	Overloading that increases electrical current and winding temperature, potentially causing burnout.

Table 3 presents the initial FMEA identification of component failure modes and the associated causes that were reported or observed at the mill. These findings formed the basis for subsequent assessments of severity, occurrence, and detection.

3.2 Failure Mode and Effects Analysis (FMEA)

Following the identification of failure modes, the three FMEA ratings were determined through interviews with the chief mechanic, station operator, and maintenance staff at PMKS PT SISIRAU. The ratings were based on the reported operating conditions and expert judgments. Table 4 presents the scores and their stated criteria for all six components.

Table 4. Severity, Occurrence, and Detection Ratings for Screw Press Components

Component	Severity (S) and criterion	Occurrence (O) and criterion	Detection (D) and criterion
Bearing	7 — Reduced primary function	6 — Every 3,000 h (4 months)	3 — Likely to be detected
Main shaft	10 — Complete shutdown	5 — Every 5,000 h (1 year)	1 — Certain to be detected
Worm screw	7 — Reduced primary function	7 — Every 1,000 h (2 months)	4 — Very likely to be identified
Press cage	7 — Reduced primary function	6 — Every 3,000 h (4 months)	4 — Very likely to be identified
Hydraulic system	6 — Abnormal equipment operation	3 — Every 20,000 h (4 years)	3 — Likely to be detected
Electric motor	8 — Loss of primary function	2 — Every 30,000 h (5 years)	3 — Likely to be detected

As shown in Table 4, the main shaft has the highest severity score (S = 10), reflecting the possibility of a complete shutdown if the shaft fractures. The worm screw has the highest occurrence score (O = 7), corresponding to the stated frequency of approximately one failure per 1,000 operating hours. Detection scores range from 1 to 4 in the ratings reported by the respondents, suggesting that some warning signs may be recognizable before severe damage occurs. These interpretations should be considered in light of the study's judgment-based scoring method.

3.3 Risk Priority Number (RPN) Assessment

RPN values were calculated by multiplying the Severity, Occurrence, and Detection scores for each component. The resulting scores were used to rank components and guide preventive maintenance priorities, as presented in Table 5.

Table 5. Component RPN Scores and Risk Rankings

Rank	Component	Failure mode	S	O	D	RPN	Risk level
1	Worm screw	Fracture	7	7	4	196	Very high
2	Press cage	Wear	7	6	4	168	Very high
3	Bearing	Fracture	7	6	3	126	Very high
4	Hydraulic system	Wear	6	3	3	54	Moderate
5	Main shaft	Fracture	10	5	1	50	Low
6	Electric motor	Burnout	8	2	3	48	Low

The worm screw has the highest RPN (196), followed by the press cage (168) and bearing (126); all three are classified as very high risk. The hydraulic system has an RPN of 54 and is classified as moderate risk, while the main shaft (50) and electric motor (48) fall within the low-risk category according to the thresholds used in this study. These results place components directly involved in pressing among the highest priorities for preventive maintenance.

High operating loads, continuous friction, and the entry of foreign materials were identified as factors contributing to the risks associated with the worm screw, press cage, and bearing. Failures in these components may disrupt oil extraction and increase oil losses. Hydraulic system wear may result from sustained pressure and oil contamination, while main shaft fractures or electric motor burnout may cause complete stoppages despite their lower RPN rankings. Thus, RPN prioritization should not obscure the potential severity of less frequent failures.

To translate the risk assessment into operational recommendations, the reported failure modes, causes, effects, and preventive measures were brought together in Table 6.

Table 6. Failure Modes, Effects, and Recommended Preventive Maintenance

Component	Failure mode	Likely cause	Potential effect	Recommended preventive measure
Worm screw	Fracture	Foreign objects (stones or metal) entering the press, or fruit material that is too hard.	Reduced oil extraction performance and increased oil losses.	Install a magnetic separator on the conveyor; conduct routine visual inspections; replace the component at an appropriate interval.
Press cage	Wear	Continuous friction with fruit fibres and high operating pressures.	Fibre residue leakage, reduced pressure, and incomplete pressing.	Perform regular cleaning and clearance checks; consider hardfacing repair when feasible.
Bearing	Fracture	Insufficient greasing or shock loads beyond design capacity.	Possible machine seizure and further shaft damage.	Schedule regular or automated lubrication; periodically monitor temperature and vibration.
Hydraulic system	Wear	Hydraulic oil contaminated by dust or water, or leakage at seals.	Unstable cone pressure and inconsistent fibre residue and nut quality.	Replace oil and filters regularly; inspect hoses and seals for leakage.
Main shaft	Fracture	Metal fatigue or excessive torsional load.	Complete production stoppage and potentially lengthy major repairs.	Check shaft alignment and prevent operation above the machine's rated capacity.
Electric motor	Burnout	Overloading, unstable voltage, or water entering the windings.	Machine cannot be started, interrupting production flow.	Install an overload relay and clean dust from motor cooling fins.

The measures in Table 6 provide a basis for shifting from breakdown maintenance toward preventive maintenance at the pressing station. For very-high-risk components,

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mechanical protection and inspection are key measures, including foreign-material separation and repair of wear-prone surfaces where appropriate. For bearings and the hydraulic system, consistent lubrication, condition monitoring, and oil cleanliness are emphasized. Standardizing these activities in the station's maintenance procedures may help reduce interruptions and avoidable oil losses, although their effects were not measured after implementation in this study.

4. Conclusion

The FMEA assessment identified six screw press components with potential failure modes at PMKS PT SISIRAU: the worm screw, press cage, bearing, hydraulic system, main shaft, and electric motor. The worm screw ranked first with an RPN of 196, followed by the press cage (168) and bearing (126); all three were classified as very high risk. Heavy loading, continuous friction, and possible foreign-material entry were identified as principal contributing factors.

Failures of the critical components may compromise oil extraction efficiency, increase oil losses, and disrupt production continuity. Proposed preventive measures include installing a magnetic separator, conducting routine visual inspections, scheduling lubrication and condition monitoring, periodically replacing oil and filters, controlling operating loads, and replacing worn components at appropriate intervals. These recommendations aim to improve screw press reliability and reduce production interruptions; their actual effectiveness remains to be evaluated.

The study is limited by the subjective nature of FMEA ratings, the absence of quantified impacts on oil losses, downtime, and costs, and the limitations of RPN as a stand-alone measure of risk. Future research could evaluate outcomes after implementation, estimate economic and downtime effects, test score sensitivity across respondents, and compare RPN-based ranking with Action Priority or other weighting methods.

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