

ANALYSIS OF DAMAGE TO THE HITACHI ZAXIS 330 EXCAVATOR MACHINE USING THE FMEA METHOD (Case Study: PT. Koperasi Pertambangan Bara Sumber Makmur)

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Abstract

Maintenance merupakan fungsi penting dalam industri pertambangan yang berperan menjaga kontinuitas operasi produksi. PT. Koperasi Pertambangan Bara Sumber Makmur, perusahaan pertambangan batu bara di Kabupaten Kutai Kartanegara, Kalimantan Timur, menggunakan Excavator Hitachi Zaxis 330 sebagai salah satu alat berat utamanya. Berdasarkan hasil observasi, kerusakan komponen mesin terjadi setiap 3–6 bulan sehingga menyebabkan breakdown, menurunkan produktivitas, dan menghambat pencapaian target produksi. Penelitian ini bertujuan mengidentifikasi komponen kritis, mengukur tingkat risiko kegagalan, serta memberikan usulan perbaikan menggunakan metode Failure Mode and Effect Analysis (FMEA). Data dikumpulkan melalui observasi, wawancara, dan kuesioner kepada mekanik dan pengawas lapangan, kemudian diolah dengan menghitung nilai Risk Priority Number (RPN) dari perkalian severity, occurrence, dan detection. Hasil pengolahan data mengidentifikasi 19 potensi kegagalan pada 19 komponen, dan dengan bantuan diagram Pareto (prinsip 80/20) diperoleh enam komponen prioritas. Empat komponen dengan nilai RPN tertinggi adalah Injection Pump (RPN 378), Oil Pump (RPN 315), Gasket Kit Overhaul (RPN 252), dan Blok Cylinder Assy (RPN 252). Analisis fishbone menunjukkan penyebab dominan kerusakan berasal dari aspek man, method, dan machine. Usulan perbaikan berupa penjadwalan perawatan preventif secara rutin, pengecekan berkala bahan bakar pada injection pump, pergantian oli secara terjadwal pada oil pump, serta pelatihan (training) bagi mekanik baru guna menurunkan frekuensi kerusakan dan menjaga produktivitas mesin.

Kata Kunci: FMEA, Risk Priority Number, Excavator Hitachi Zaxis 330, Maintenance, Usulan Alternatif Solusi

1. INTRODUCTION

Coal is a combustible organic mineral formed from the remains of ancient plants through physical and chemical processes over millions of years. Coal mining activities require the support of heavy equipment for tasks such as excavation, hauling, compaction, and material transfer. The availability and reliability of heavy equipment are therefore key factors that influence the achievement of production targets.

PT. Koperasi Pertambangan Bara Sumber Makmur is a coal mining company established in 2018 and operating in Kutai Kartanegara Regency, East Kalimantan. The company operates eight excavator units, four of which are of the Hitachi Zaxis 330 type, used to dig soil, level surfaces, and move heavy materials, including coal. Because of its direct impact on production output, this heavy equipment has become a primary focus of the company's maintenance activities.

Based on preliminary observation, the Hitachi Zaxis 330 Excavator frequently experiences breakdowns due to component damage. Such damage halts coal hauling activities, prolongs downtime, and ultimately reduces the company's productivity and revenue. Repairs are generally carried out only after a component has actually failed (corrective maintenance), causing a relatively long repair time.

According to Dewi and Prasanti (2022), *Failure Mode and Effect Analysis* (FMEA) is a method used to identify, recognise, and reduce failures in a production process before distribution. The FMEA method is considered suitable for this problem because it can map the types of failure and their causes,

and provides a priority ranking for handling based on the *Risk Priority Number* (RPN), which is calculated from the multiplication of *severity*, *occurrence*, and *detection* (Rinoza et al., 2021).

Based on this problem, this research aims to: (1) identify the components that significantly affect the performance of the Hitachi Zaxis 330 Excavator; (2) determine the level of failure risk of the machine; and (3) provide appropriate improvement proposals for the maintenance of its components.

2. LITERATURE REVIEW

2.1 Maintenance

According to Stephens (2004) in Nasution et al. (2021), *maintenance* is a function in the manufacturing industry that is as important as the production function itself. Maintenance activities include inspection, lubrication, repair of damage, and adjustment or replacement of *spare parts* so that the machine remains operable and production continuity is guaranteed. The types of maintenance include *corrective*, *preventive*, *predictive*, and *breakdown maintenance* (Hermawan & Jaya, 2022).

2.2 FMEA (Failure Mode and Effect Analysis)

FMEA is a system design evaluation technique that identifies component failures and analyses their consequences on system reliability (Smith & Glenn, 2004 in Sintia et al., 2021). The objective of FMEA is to classify failures based on the RPN value so that improvements can be prioritised. The RPN is obtained from the multiplication of three factors:

- a. *Severity* — the severity level of the effect caused by the failure mode, rated on a scale from 1 (no effect) to 10 (hazardous);
- b. *Occurrence* — the frequency of failure occurrence, assessed by the time between events (more than three years up to less than one month);
- c. *Detection* — the ability to detect a failure before it has an impact, rated from 1 (easily detected) to 10 (undetected).

2.3 Pareto Diagram and Fishbone Diagram

The Pareto principle, or the 80/20 rule, states that approximately 80% of effects are caused by only 20% of the causes (Sunarto & Santoso, 2020). In this research, the Pareto diagram is used to filter priority components based on their RPN values. The Fishbone (Ishikawa) diagram is used to analyse the root causes of damage by grouping them into categories such as Man, Machine, Material, and Method (Kristiono, 2019 in Silka, 2022).

2.4 Heavy Equipment and the Hitachi Zaxis 330 Excavator

Heavy equipment refers to mechanical machines designed to perform construction functions, operated either automatically or manually (Bagaskara & Aditya, 2023). An *excavator* is used for moving material, digging trenches/foundations, levelling ground surfaces, and excavating mining materials. The Hitachi Zaxis 330 Excavator is a modern construction machine capable of loading up to 1.8 tons of material and is widely used in the mining sector (Sarwandy & Royan, 2021).

3. RESEARCH METHODOLOGY

3.1 Research Location and Time

The research was conducted at PT. Koperasi Pertambangan Bara Sumber Makmur, located at Jalan H. Adam Malik, Karang Asam Ulu Sub-district, Sungai Kunjang District, Samarinda, while the mining site is located at Jalan Jenderal Sudirman, Loa Kulu Kota, Kutai Kartanegara Regency, East Kalimantan. The research was conducted over five months, from July to December 2025.

3.2 Data Collection

Primary data were obtained through direct observation of the operational process of the Hitachi Zaxis 330 Excavator, interviews with the head mechanic and field supervisor, and questionnaires used to assess severity, occurrence, and detection values for each component. Secondary data consisted of the company profile and historical machine-damage records for the period January to December 2024.

3.3 Data Processing

The data processing stages using the FMEA method were as follows: (1) identifying potential failures of each machine component; (2) recording the effects arising from the failures; (3) determining the causes of failure; (4) assigning severity, occurrence, and detection ratings based on the FMEA criteria tables; (5) calculating the RPN value through the multiplication $S \times O \times D$; (6) ranking the RPN values and filtering priority components using a Pareto diagram; and (7) analysing the causes of priority components using a Fishbone diagram to formulate improvement proposals.

4. RESULTS AND DISCUSSION

4.1 Failure Identification and RPN Calculation

Based on the observations, interviews, and questionnaires, 19 types of failures were identified across 19 components of the Hitachi Zaxis 330 Excavator. The RPN value for each component is presented in Table 1.

Table 1. RPN Calculation Results

No.	Component	Failure Mode	S	O	D	RPN
1	Injection Pump	Dirty fuel	7	6	9	378
2	Oil Pump	Contaminated oil	7	5	9	315
3	Gasket Kit Overhaul	Damaged gasket kit	6	6	7	252
4	Cylinder Block Assy	Cracked cylinder block	7	6	6	252
5	Piston Engine	Cracked piston	5	7	6	210
6	Connection Rod	Loose bolt	5	7	6	210
7	Gear Cam Shaft	Wear	5	6	6	180
8	Cover CYL Head	Cover head wear	6	5	5	150
9	Cylinder Head Assy	Damaged cylinder	6	5	5	150
10	Gear Ring	Gear ring wear	5	7	4	140
11	Pin Piston Engine	Broken piston pin	4	7	5	140
12	Ring Piston Engine	Wear	4	6	5	120
13	Gear Cam Shaft	Wear	3	6	6	108
14	Metal Jalan Engine	Broken running metal	4	6	4	96
15	Bushing Con Rod	Broken bushing	3	6	5	90
16	Liner Engine	Broken liner	3	5	5	75
17	Cam Shaft	Cam shaft wear	3	5	5	75
18	Crankshaft	Crankshaft wear	3	6	4	72
19	Metal Duduk Engine	Broken seating metal	2	6	5	60

4.2 Pareto Diagram Analysis

After the RPN values were sorted in descending order, the percentage and cumulative percentage were calculated to apply the 80/20 Pareto principle. Table 2 shows the percentage and cumulative percentage results that form the basis for determining the priority components.

Table 2. Percentage and Cumulative Calculation of RPN Values

No.	Component	RPN	% Total	% Cumulative
1	Injection Pump	378	13.20%	13.20%
2	Oil Pump	315	11.00%	24.20%
3	Gasket Kit Overhaul	252	8.80%	33.10%
4	Cylinder Block Assy	252	8.80%	40.33%
5	Piston Engine	210	7.33%	47.66%
6	Connection Rod	210	7.33%	54.99%
7	Gear Cam Shaft	180	6.28%	61.27%
8	Gear Cam Shaft	180	6.28%	65.80%

No.	Component	RPN	% Total	% Cumulative
9	Cover CYL Head	150	5.23%	66.50%
10	Cylinder Head Assy	150	5.23%	71.73%
11	Gear Ring	140	4.88%	76.61%
12	Pin Piston Engine	140	4.88%	81.49%
13	Ring Piston Engine	120	4.19%	85.68%
14	Gear Cam Shaft	108	3.77%	89.45%
15	Metal Jalan Engine	96	3.35%	92.80%
16	Bushing Con Rod	90	3.14%	95.94%
17	Liner Engine	75	2.61%	98.66%
18	Cam Shaft	75	2.61%	99.72%
19	Crankshaft	72	2.51%	100.00%
	Total	2,863	100.00%	

Based on the 80/20 Pareto principle, the top six components are the priority focus because they represent the largest portion of the cumulative RPN value, namely the Injection Pump, Oil Pump, Gasket Kit Overhaul, Cylinder Block Assy, Piston Engine, and Connection Rod. For the most critical handling, the four components with the highest RPN values are further analysed using the Fishbone diagram.

4.3 Critical Component Analysis Using the Fishbone Diagram

4.3.1 Injection Pump (RPN = 378)

The causes of Injection Pump damage are examined from four aspects. Man: a lack of knowledge and experience among workers due to the absence of a training programme, especially for new workers. Method: no preventive maintenance programme is in place, so the handling is reactive. Material: poor material quality of the injection pump makes the component prone to damage. Machine: a lack of fuel-quality inspection and the absence of a routine maintenance schedule.

4.3.2 Oil Pump (RPN = 315)

The primary cause from the Man aspect is the limited knowledge of workers due to the absence of training. Method: no maintenance programme has been established, so when damage occurs, work is halted while waiting for repair. Machine: oil replacement is not performed routinely and there is no component maintenance schedule, which is why oil-pump clogging is not detected early.

4.3.3 Gasket Kit Overhaul (RPN = 252)

On the Man aspect, workers have limited understanding of component maintenance due to the absence of training. Method: no scheduled maintenance programme is available. Machine: a leaking system causes the machine to overheat, triggered by a lack of routine inspection and scheduled gasket replacement.

4.3.4 Cylinder Block Assy (RPN = 252)

Man: insufficient worker knowledge in component maintenance due to the absence of training. Method: the absence of a maintenance programme means that sudden damage delays operations. Machine: the lack of a maintenance schedule causes recurring damage to the Cylinder Block Assy to go unidentified early.

4.4 Improvement Proposals

Based on the Fishbone diagram analysis, four improvement proposals are formulated to reduce the damage rate of the Hitachi Zaxis 330 Excavator components:

- a. Injection Pump: implement routine maintenance and a scheduled inspection of fuel quality to prevent dirt contamination in the injection system.
- b. Oil Pump: perform scheduled oil replacement according to plan to prevent dirty oil from clogging the oil pump.
- c. Cylinder Block Assy: apply regular maintenance, inspect the cylinder routinely, and use hydraulic oil that meets the standard specification.
- d. Gasket Kit Overhaul: carry out periodic inspection of the gasket and sealing system to prevent leakage and engine overheating.

In addition to the four points above, the company is advised to establish a training programme for mechanics — especially new workers — and to prepare a Standard Operating Procedure (SOP) for scheduled preventive maintenance. These measures are expected to reduce breakdown frequency, extend component life, and maintain the productivity of the Hitachi Zaxis 330 Excavator.

5. CONCLUSION

Based on the damage analysis of the Hitachi Zaxis 330 Excavator using the FMEA method at PT. Koperasi Pertambangan Bara Sumber Makmur, three main conclusions are drawn. First, 19 components and 19 types of failure were identified as potentially affecting machine performance, with six components classified as priority based on the Pareto diagram. Second, the four components with the highest failure-risk levels are the Injection Pump (RPN 378), Oil Pump (RPN 315), Gasket Kit Overhaul (RPN 252), and Cylinder Block Assy (RPN 252).

Third, the improvement proposals include scheduled preventive maintenance, routine fuel inspection of the Injection Pump, scheduled oil replacement of the Oil Pump, regular inspection of the Cylinder Block Assy using hydraulic oil that meets the standard specification, and periodic maintenance of the Gasket Kit Overhaul. The implementation of these proposals, supported by a training programme for mechanics, is expected to reduce the frequency of damage and maintain production continuity. Further research is recommended to design a more detailed maintenance schedule and to compare the FMEA method with other maintenance methods, such as Reliability Centered Maintenance (RCM).

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