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Detection of Damage Motor and Coal Crusher in Power Plant *Tanjung Enim* 3 X 10 MW Using Vibration Analysis

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ABSTRACT

Motor and coal crushers are critical in coal size reduction for efficient energy production. Continuous operation often impacts their functionality, necessitating effective maintenance methods. This study employs vibration analysis to monitor the health and detect potential faults in the motor and coal crusher. Vibration values, measured under load and no-load conditions, were analyzed in vertical, horizontal, and axial directions using ISO 10816 standards. Results show that while vibration levels remained within safe limits, increased readings in specific areas, particularly at the Crusher NDE in axial direction under load conditions, suggest potential issues like misalignment or bearing wear. Prominent vibration peaks at lower frequencies in the spectrum further support these findings. This research underscores the importance of routine vibration monitoring to preemptively address machine faults, ensuring optimized operation and minimized downtime. Vibration analysis proves effective for predictive maintenance and operational reliability in coal processing systems.

KEYWORDS: *Motor, Coal Crusher, Vibration Analysis, Vibration Spectrum, Measurement.*

1.0 INTRODUCTION

Coal crushers play a crucial role in energy production by breaking coal into specific sizes suitable for transportation to bunkers and boilers. These machines consist of three main components: the motor, fluid coupling, and crusher. The motor drives the crusher through a shaft and fluid coupling mechanism, facilitating continuous coal processing. In energy plants like Tanjung Enim, coal crushers are essential for maintaining a steady supply of fuel for power generation. However, their continuous operation subjects them towear and tear, reducing reliability and increasing the likelihood of failures without adequate maintenance [1]. Failures in coal crushers can disrupt energy production, highlighting the need for effective predictive maintenance strategies.

Vibration analysis has become a key predictive maintenance tool across various industries. It measures oscillations in mechanical or structural systems, using the principles of energy dissipation and equilibrium forces [2]. Historically, vibration analysis has evolved as a diagnostic tool, providing actionable insights into machine health by detecting faults such as misalignment, imbalance, and bearing wear. Standards such as ISO 10816 have been developed to classify vibration levels, offering clear benchmarks for machine condition assessment [3]. These standards guide operators in identifying abnormalities and preventing catastrophic failures. By using vibration analysis, operators can schedule timely repairs, extend equipment lifespan, and reduce maintenance costs [4].

This study aims to analyze vibration characteristics in coal crushers, specifically focusing on motor and crusher performance under load and no-load conditions. Previous research has demonstrated the efficacy of vibration analysis in diagnosing faults in industrial machinery, yet studies focusing specifically on coal crushers are limited [5][6]. By leveraging ISO 10816 standards, this research seeks to fill the gap by providing detailed insights into the vibration profiles of coal crushers, identifying early signs of wear and misalignment, and offering recommendations for improved predictive maintenance. This study builds on prior works and underscores the critical importance of adopting advanced diagnostic tools in the energy sector to ensure operational stability and reliability [7].

2.0 RESEARCH METHOD

2.1 System Configuration and Operational Principles

The motor and coal crusher are connected via a shaft with a fluid coupling mechanism, ensuring the transmission of rotational energy for crushing coal into smaller sizes suitable for further processing. When energized, the motor generates rotational movement transmitted through the shaft and coupling to the crusher. This continuous movement enables coal crushing, while also producing vibrations inherent to the system's operation.

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2.2 Vibration Measurement Procedures

The study measured vibrations at the Drive End (DE) and Non-Drive End (NDE) of the motor and crusher under two distinct operational conditions: no-load (unloaded) and load (loaded). Measurements were conducted using the *Vibscanner Pruftechnik* 5.400, a highly precise instrument, with the probe strategically placed to capture vibrations in vertical, horizontal, and axial directions. These positions correspond to critical axes for detecting misalignments, imbalances, and bearing wear. Figures 1 and 2 illustrate the setup and measurement areas.

Figure 1: Motor and Coal Crusher

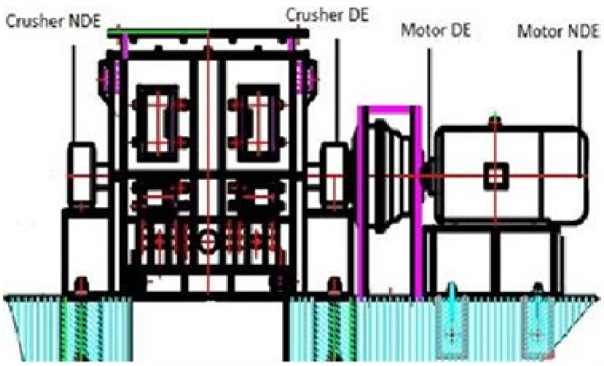

Figure 2: Area of measurement motor and coal crusher

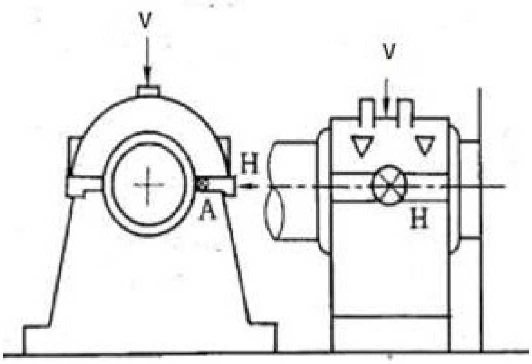

Figure 3: Probe position standard

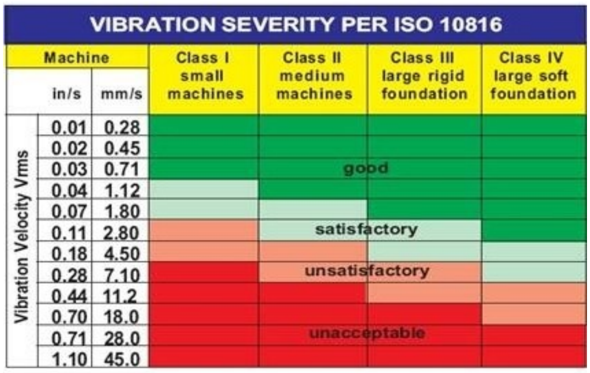

Figure 4: ISO 10816 vibration standard

2.3 Justification for Measurement Standards

Vibration values were analyzed using ISO 10816 standards, which classify machine conditions based on acceptable vibration levels. This standard ensures consistency in evaluation and provides a benchmark for machine health, aligning with global best practices in maintenance [8][9]. Adjustments to the measured values were made to compare them with these tolerance levels, as shown in Figure 3 and Probe Position Standard can be seen in Figure 4.

2.4 Data Analysis Techniques

The vibration data were processed using Fast Fourier Transform (FFT) to convert time-domain signals into frequency-domain spectra. FFT enables the decomposition of complex vibration signals into frequency peaks, making it easier to identify specific faults such as imbalance, misalignment, or bearing issues. Frequency-domain analysis, as compared to the time domain, provides enhanced clarity by isolating contributions from different components, such as bearings or gears, to overall vibration [10] [11]. Figures 5 and 6 depict the vibration spectrum shapes in both time and frequency domains.

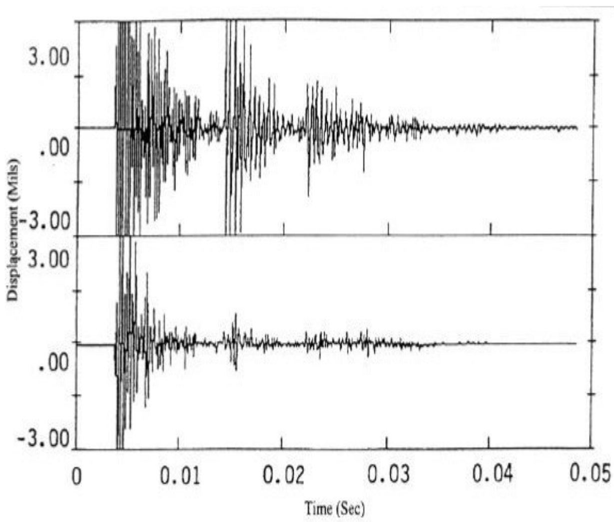

Figure 5: Vibration spectrum based on time domain

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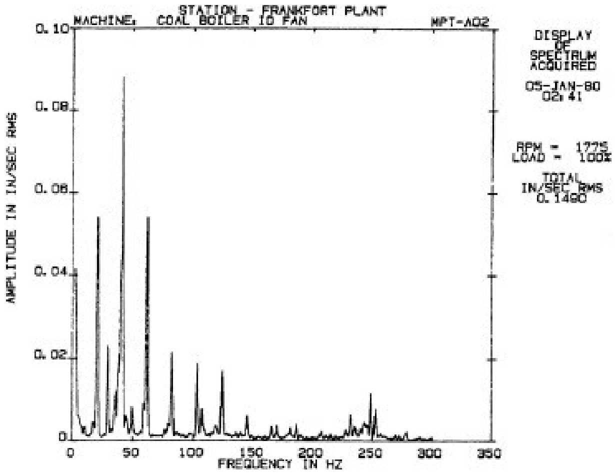

Figure 6: Vibration spectrum based on frequency domain

The chosen methodology combines reliable equipment and internationally recognized standards, ensuring robust and repeatable results. The *Vibscanner Pruftechnik* 5.400 offers precise readings essential for industrial diagnostics. ISO 10816 provides a globally accepted framework for machine condition classification, enhancing the study's credibility. The FFT, a cornerstone of vibration analysis, facilitates a detailed understanding of machine faults, offering actionable insights for maintenance planning. By employing this approach, the study ensures that findings are both scientifically sound and practically applicable.

3.0 RESULT AND DISCUSSION

3.1 Vibration Measurements, Load and No-Load Conditions

Vibration measurements were conducted using the *Vibscanner Pruftechnik* 5.400, capturing data under unloaded and loaded conditions. The results are summarized in Tables 1 and 2, highlighting the highest and lowest vibration values for each condition. In the unloaded condition, the crusher NDE in the axial direction exhibited the largest vibration value (5.60 mm/s), while the Motor Axial recorded the smallest value (0.54 mm/s). Under load conditions, the largest vibration value was observed again in the crusher NDE axial direction, increasing to 6.61 mm/s, while the smallest value was in the Motor Axial (1.12 mm/s).

The overall vibration levels remained within the maximum operational safe limit of 7.1 mm/s as prescribed by ISO 10816-1. However, the increase in axial vibration at the Crusher NDE under load suggests the presence of operational stressors that may require further monitoring to prevent potential damage.

3.2 Data Interpretation and Implications

The vertical vibration levels in both unloaded and loaded conditions were generally higher at the Crusher DE compared to other measurement points. This pattern indicates that the Crusher DE is subjected to higher operational stress, possibly due to the nature of its load-bearing function. Notably, vertical vibrations slightly decreased when a load was applied, suggesting stabilization under load conditions, potentially due to balancing forces during operation.

Table 1: Measurement of vibration in motor and coal crusher for unload condition

Vibration Velocity	Area Measurement			
	Motor DE	Motor NDE	Crusher DE	Crusher NDE
Vertical (mm/s)	4.61	3.27	5.17	3.63
Horizontal (mm/s)	2.16	1.48	2.77	2.47
Axial (mm/s)	0.54	1.19	4.80	5.60

Table 2: Measurement of vibration in motor and coal crusher for load condition

Vibration Velocity	Area Measurement			
	Motor DE	Motor NDE	Crusher DE	CrusherN DE
Vertical (mm/s)	3.94	2.79	4.34	3.26
Horizontal (mm/s)	2.93	3.06	2.63	3.02
Axial (mm/s)	1.12	1.82	4.06	6.61

Horizontal vibration levels exhibited an increase at the Motor DE and Motor NDE areas under load, pointing to potential issues such as mounting looseness or misalignment that become more pronounced during operational stress [12]. On the other hand, the horizontal vibrations at the Crusher remained relatively stable between unloaded and loaded conditions, reflecting a more balanced horizontal setup for the crusher assembly.

Axial vibrations consistently peaked at higher levels in the Crusher compared to the Motor. The notable increase in axial vibration at the Crusher NDE under load conditions, reaching 6.61 mm/s, is indicative of possible misalignment, bearing wear, or structural issues. These observations underscore the importance of continued vibration monitoring, particularly in critical areas such as the Crusher NDE. The high axial vibrations can indicate misalignment, bearing wear, or structural issues. The result of spectrum of each measurement in motor and coal crusher in without load condition can be seen in Figure 7-10.

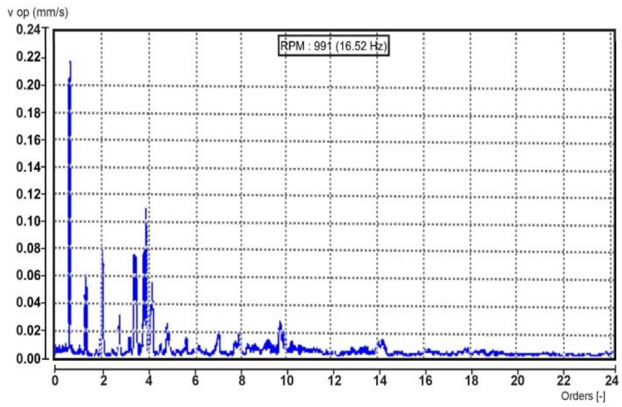

Figure 7: Vibration spectrum motor DE without load condition

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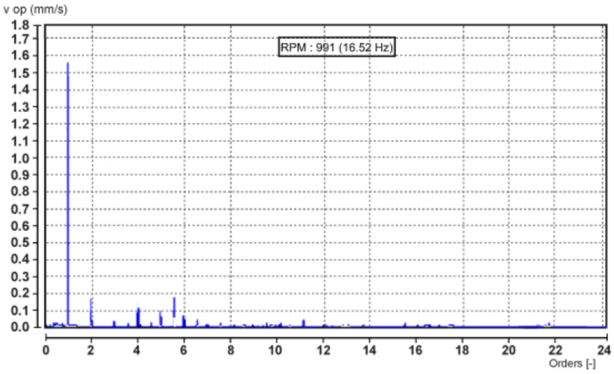

Figure 8: Vibration spectrum motor NDE without load condition

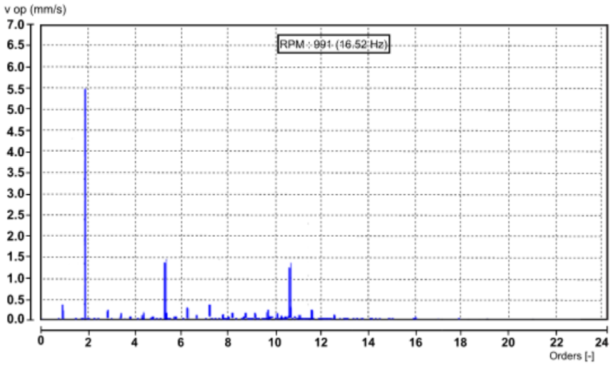

Figure 9: Vibration spectrum coal crusher DE without load condition

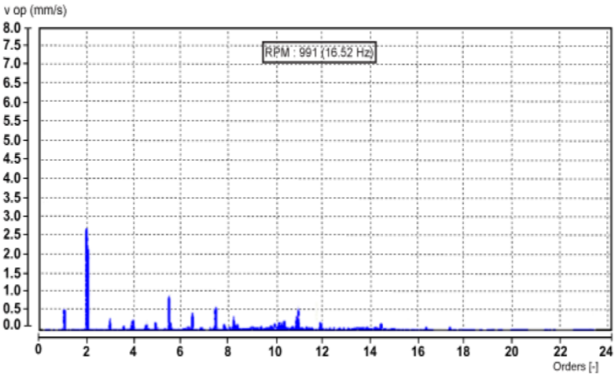

Figure 10: Vibration spectrum coal crusher NDE without load condition

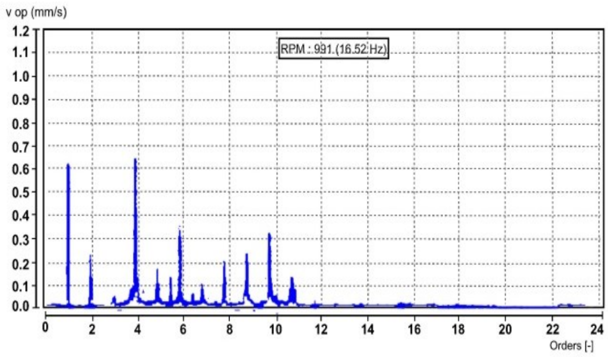

Figure 11: Vibration spectrum motor DE with load condition

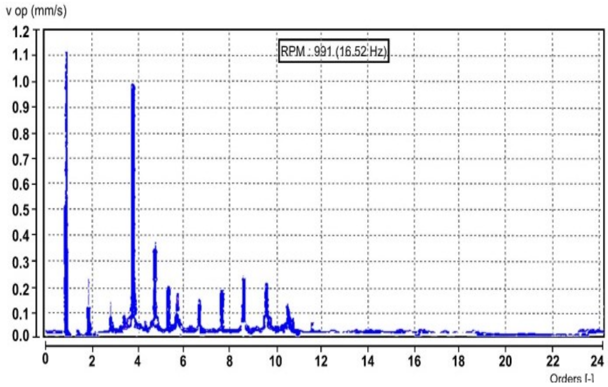

Figure 12: Vibration spectrum motor NDE with load condition

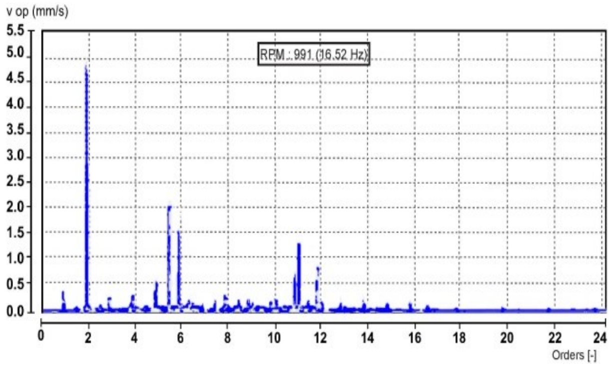

Figure 13: Vibration spectrum coal crusher DE with load condition

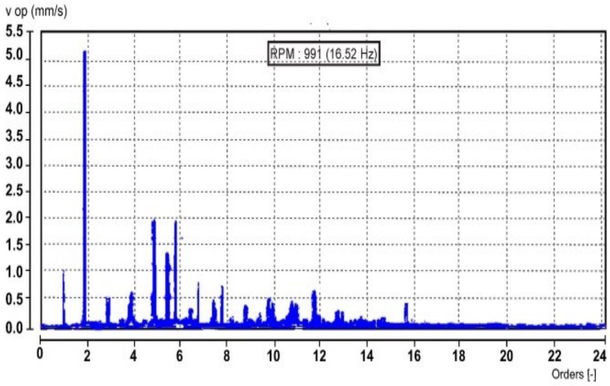

Figure 14: Vibration spctrum coal crusher NDE with load condition

3.3 Frequency Spectrum Analysis

The frequency spectrum analysis further supports these findings. In the unloaded condition, as shown in Figures 7–10, prominent peaks at lower frequencies were observed in the Motor DE and Crusher DE spectra. These peaks often correlate with issues like imbalance, particularly when they occur near the machine's fundamental running speed (1x RPM) or its harmonics (2x, 3x RPM) [13][14]. The Motor NDE spectrum appeared relatively stable with low amplitude across frequencies, indicating minimal mechanical stress at this point [15].

In Figure 7 depicted the motor DE, which shown a series of prominent peaks at lower frequencies. High peaks at low frequencies were often indicative of issues like imbalance, especially if they occur at or near the machine's fundamental in certain running speed. The motor NDE measurement point shown in Figure 8, appeared relatively stable with low amplitudes across the spectrum, suggesting minimal vibration at this point. This could indicate that the motor's non-drive end is not experiencing significant mechanical stress [12], which is generally expected. Low readings here usually imply that the main sources of vibration are on the drive end or other parts of the machine [13].

Figure 9 depicted the coal crusher side, which the measurement point on drive end has noticeable peaks, possibly higher than those on the motor. Peaks at specific frequencies could indicate issues within the crusher, such as imbalance or component wear. If any peaks align with multiples of the running speed, it could signal issues like rotor imbalance or misalignment in the crusher assembly [15]. In Figure 10 shows the coal crusher non drive end has low amplitude levels, indicating stable conditions at this measurement point. Minimal vibration suggests that the non-drive end of the crusher is not currently subjected to significant mechanical issues [16].

Under load conditions (Figures 11–14), the frequency spectra showed distinct peaks at regular intervals, particularly at the motor DE and crusher NDE. High peaks at the fundamental frequency and its harmonics are indicative of misalignment or imbalance in rotating components [17]. Interestingly, the crusher DE spectrum under load exhibited less pronounced peaks, suggesting a reduction in vibration severity compared to the motor DE. However, moderate peaks in the crusher NDE spectrum highlight areas requiring closer attention [18].

Figure 11 and Figure 12 show the distinct peaks at regular intervals, especially at lower frequencies. These peaks might correspond to multiples of the machine's fundamental running frequency (harmonics). High peaks at the fundamental frequency and its multiples can indicate imbalance or misalignment in rotating components [19]. But, in Figure 13 shows the peaks were less pronounced than in the first two graphs, though there is a notable peak at a low frequency. The lower amplitudes could indicate less severe vibration at this measurement point, but the presence of even a few distinct peaks can suggest that monitoring for imbalance or wear [17]. Figure 14 shows a moderate pattern of peaks, especially at lower frequencies. The spectrum's layout might indicate an area with moderate vibration levels, potentially from minor misalignment or looseness. From load and unload condition in motor side shown an increase in horizontal and axial vibrations under load, especially in the motor DE area. The crusher side exhibits a moderate increase in axial vibrations, particularly at crusher NDE, suggesting that load application is amplifying certain axial forces within the crusher [18].

3.4 Limitations and Recommendations

The study confirms that vibration levels remain within established safety thresholds, ensuring compliance with operational standards. However, the observed increases in specific vibration metrics, particularly the axial vibration at the Crusher Non-Drive End (NDE), warrant closer examination. These changes may signal the onset of mechanical irregularities or early-stage wear in the system. Proactive monitoring and further diagnostic analysis are recommended to mitigate potential risks and maintain equipment reliability. The limitations of the study include the lack of long-term monitoring data, which could provide insights into trends and progressive changes in vibration levels. Additionally, environmental factors and variations in coal quality were not accounted for, which may influence vibration behavior. To address these limitations, it is recommended that future studies incorporate continuous monitoring systems and expand the scope to include additional operational variables [20]. Regular vibration analysis, combined with predictive maintenance practices, will ensure early detection of faults and enhance the reliability of coal crusher systems.

4.0 CONCLUSION

The study demonstrated that while the coal crushers at *Tanjung Enim* operate within safe vibration thresholds, certain areas, particularly crusher NDE, exhibit signs of potential mechanical issues. Axial vibration increases highlight the need for attention to misalignment or looseness. Regular vibration analysis, aligned with ISO 10816 standards, proves effective in maintaining machine reliability, optimizing performance, and reducing unexpected failures. Future research should integrate advanced diagnostic tools and machine learning for enhanced fault detection. Comparative analyses with coal crushers in similar settings would also provide deeper insights into best maintenance practices.

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