Journal Renewable Energy & Mechanics (REM)
Vol. 06 No.02 2023
DOI: 10.25299/rem.2023.vol6(02).11972
E-ISSN: 2614-8315
P-ISSN: 2714-621X
Received 2023-02-07; Accepted 2023-09-10

VIBRATION ANALYSIS OF FIRE PUMP OF PEM AKAMIGAS CEPU: A CASE STUDY

(ANALISIS GETARAN PADA POMPA PEMADAM KEBAKARAN PEM AKAMIGAS CEPU: STUDI KASUS)

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ABSTRACT

Fire pump is a pump that is used to move water from the firewater reservoir to the location of the fire. If there is damage to this pump, the fire that occurs cannot be resolved quickly so that the impact of damage caused by fire becomes more widespread. Various problems can occur in the operation of the pump, one of which is damage to the bearings and shaft, noise occurs, decreased capacity, and even a decrease in pump efficiency. So to prevent the risk of greater damage and minimize losses in terms of cost and time, it is necessary to carry out maintenance. One of the efforts to detect damage to the pump is by vibration analysis, where from the vibration characteristics that occur, the type of damage can be determined. The purpose of this study was to determine the vibration characteristics that occur in the PEM Akamigas Cepu fire pump, by monitoring conditional vibrations using a vibration analyzer. The method is to attach the transducer to a predetermined location to determine the vibration spectrum that occurs in the axial, radial and tangential directions, then analyze the type of damage so that appropriate maintenance actions can be taken. As a result, this pump is indicated to be experiencing extreme looseness or bearing clearance problems at the pump drive end and pump non drive end as well as experiencing moderate pump imbalance, so it needs to be repaired immediately to avoid more serious damage.

Keywords : fire pump, maintenance, problems, vibration, vibration analyzer

ABSTRAK

Pompa pemadam kebakaran merupakan pompa yang digunakan untuk memindahkan air dari bak penampung air pemadam menuju ke lokasi kebakaran. Jika terjadi kerusakan pada pompa ini, kebakaran yang terjadi tidak dapat diatasi dengan cepat sehingga dampak kerusakan akibat kebakaran menjadi semakin luas. Berbagai masalah dapat terjadi dalam pengoperasian pompa, salah satunya adalah kerusakan pada bantalan maupun poros nya, timbul suara bising, kapasitas turun, dan bahkan terjadi penurunan efisiensi pompa. Sehingga untuk mencegah terjadinya risiko kerusakan yang lebih besar dan meminimalkan kerugian dari segi biaya dan waktu, perlu dilakukan pemeliharaan. Salah satu usaha mendeteksi terjadinya kerusakan pada pompa adalah dengan Analisa getaran, dimana dari karakteristik getaran yang terjadi, dapat ditentukan jenis kerusakannya. Tujuan dari penelitian ini adalah untuk mengetahui karakteristik getaran yang terjadi pada pompa pemadam kebakaran milik PEM Akamigas Cepu, dengan melakukan *pemantauan kondisional getaran menggunakan vibration analyzer. Metodenya adalah dengan menempelkan transducer pada lokasi yang telah ditentukan untuk menentukan spektrum getaran yang terjadi pada arah axial, radial dan tangensial, kemudian dianalisa jenis kerusakannya agar tindakan perawatan yang tepat bisa dilakukan. Hasilnya pompa ini terindikasi mengalami extreem looseness atau bearing clearance problem pada pump drive end dan pump non drive end serta mengalami moderate pump imbalance sehingga perlu segera dilakukan perbaikan untuk menghindari kerusakan yang lebih parah.*

Kata kunci : fire pump, getaran, perawatan, permasalahan, vibration analyzer

INTRODUCTION

Predictive maintenance is maintenance by predicting machine damage based on an analysis of the operating conditions of an equipment, predicting damage, determining further maintenance, it is very important to find out early damage that occurs to equipment before it experiences serious damage, so it does not cause greater damage (Salami et al. 2021). Predictive maintenance is usually carried out using direct observation or sophisticated equipment, as was done to find problems with damage to the sucker rod circuit, a dynamometer is used to measure the path that occurs on the SRP, and efforts are immediately made to solve the problem on the SRP (Melysa and Musnal 2019).

Another way to observe the condition of an equipment is by vibration monitoring. With vibration analysis the damage that occurs to the pump in the form of clashes, misalignment, mechanical looseness, bent shafts, bearing damage, worn gears, and cavitation can be identified for proper further treatment.

The fire pump in the Polytechnic of Energy and Mineral Akamigas area is used to distribute air to the fire hydrant or fire extinguisher system in the lecture building. If this pump is damaged, then the fire that occurs cannot be overcome quickly so that the impact of damage due to fire will be more widespread. Since the pump is operating, the noise from this pump has increased, this noise can be caused by damage to pump components or pumps that have problems causing vibration and noise, therefore it is necessary to carry out maintenance because the slightest damage can cause greater damage, structural repairs when the pump is damaged larger ones will take longer and be more expensive.

Vibration analysis to predict damage to rotating equipment has been widely carried out (EDE et al. 2010), (Tenali, Babu, and Kumar 2017), (Carnegie et al. n.d.), (Noe and McKeirnan Jr. 1996), as well as vibration analysis to research specifically or researching vibration on certain components, such as the effect of misalignment variables (Akbar et al. 2021) and vibration on motor bearings (Mara, Catur, and Zulkarnaen 2018). Vibration analysis is carried out using various techniques such as MEMs accelerometer (Chaudhury, Sengupta, and Mukherjee 2014), spectral analysis (Salami, Gani, and Pervez 2001).

In this study, a vibration analysis will be carried out to predict the initial damage of the PEM Akamigas Cepu's fire pump, using the spectrum generated by the vibration analyzer.

MATERIAL

A. Machine Damage Vibration Characteristics

The vibrations that occur will produce a spectrum. From the spectrum of running speed and lower frequency harmonics/multiple, it can be seen that the causes of vibrations in equipment such as: misalignment, imbalance and others. While the bearing frequency is FFT spectrum information to identify bearing damage that occurs at high motor speeds.

The vibration signal can be broken down into its component parts using the frequency domain. Each machine breakdown or malfunction creates a unique vibration signal, also known as a "signature", which can be used to identify machine failures such as: imbalance, bent shaft, eccentricity, misalignment, backlash, bearing malfunction (bearing defect), belt drive problem, failure gears, electrical disturbances, oil whip/spin, cavitation, shaft cracking, rotor friction, resonance, hydraulics, aerodynamic forces and others.

B. Imbalance/ Unbalance

Vibration due to rotor imbalance is probably the most common machine defect. Fortunately, easy to detect and easy to repair, for any type of imbalance the FFT spectrum will show a predominant vibration frequency of 1xRPM.

The vibration amplitude at 1xRPM will vary in proportion to the square of the rotational speed. These vibrations are always present and usually dominate the vibrational spectrum (Figure 1).

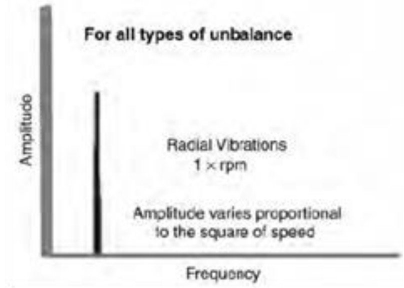


Figure 1. FFT analysis for unbalance (Jaafar A 2012).

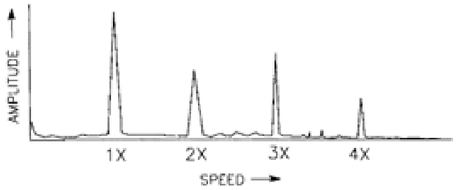


Figure 2. Double Imbalance will Produce a Consecutive Spectrum (Jaafar A 2012).

C. Mechanical Looseness

This problem is related to loose pillow block bolts, cracks in the frame structure or bearing bearings. Figures 3 and 4 show how high the harmonics are generated by the rocking motion of the pillow block with loose bolts.

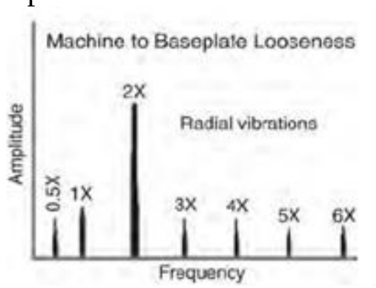


Figure 3. FFT of Mechanical Looseness (Jaafar A 2012).

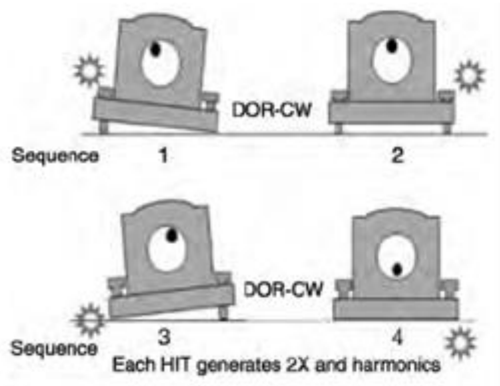


Figure 4. Illustration of Mechanical Looseness (Jaafar A 2012).

D. Parallel Misalignment

Parallel misalignment, as shown in Figure 5, results in 2 hits per cycle and therefore 2xRPM of vibration in the radial direction. Parallel misalignment has similar vibration symptoms compared to angular misalignment, but exhibits high radial vibrations approximating the 180° phase difference in the coupling as shown in Figure 6.

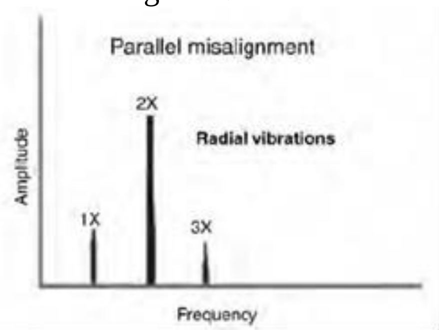


Figure 5. FFT Spectrum for Parallel Misalignment (Jaafar A 2012).

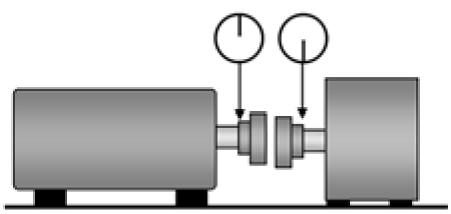


Figure 6. Coupling Position for Offset Missalignment (Jaafar A 2012).

E. Vibration Measurement Standards

The measurement standard aims to determine the permissible vibration level limit, from the measurement results it can be seen what actions we take, whether it needs repair or can it still be operated.

Various measurement standards include: ISO 10186-3, ISO 2372, American Gear Manufactures Association (AGMA), American Petroleum Institute (API), and others (Robichaud and Eng 2009).

RESEARCH METHODS/ EXPERIMENTS

A. Research Object

The object under study is a fire pump located in the area owned by PEM Akamigas Cepu, with the following specifications:

a. Pump :
   TORISHIMA PUMP
   Type CPC 100-32G
   Total Head : 135 m
   Capacity : 171 m3/h
b. Motor :
   MEZ – SIEMENS STANDARD MOTORS
   Frequency : 50Hz
   Power : 110 kW
   Rotation: 2975 rpm

Vibration analysis was performed using the Fluke-810 Vibration Tester.

B. Measurement Standard

The standard used in this study refers to the ISO 10816-3 standard – ISO Guideline for Machinery Vibration Severity. The use of ISO 10816-3 vibration standards is based on the type of machine (type and type of drive) and the foundation of the equipment, which are grouped into 4 groups, as shown in Figure 7. These include:

- Group 1: Large engines with engine power of 300 kW to 50 MW and with a rigid and flexible foundation.
- Group 2: medium engines with engine power of 15 kW to 300 kW and with rigid or flexible foundations.
- Group 3 : Radial, axial, mixed flow pump with power < 15 kW, with external driver
- Group 4: Radial, axial, mixed flow pumps with power < 15 kW, with integrated driver.

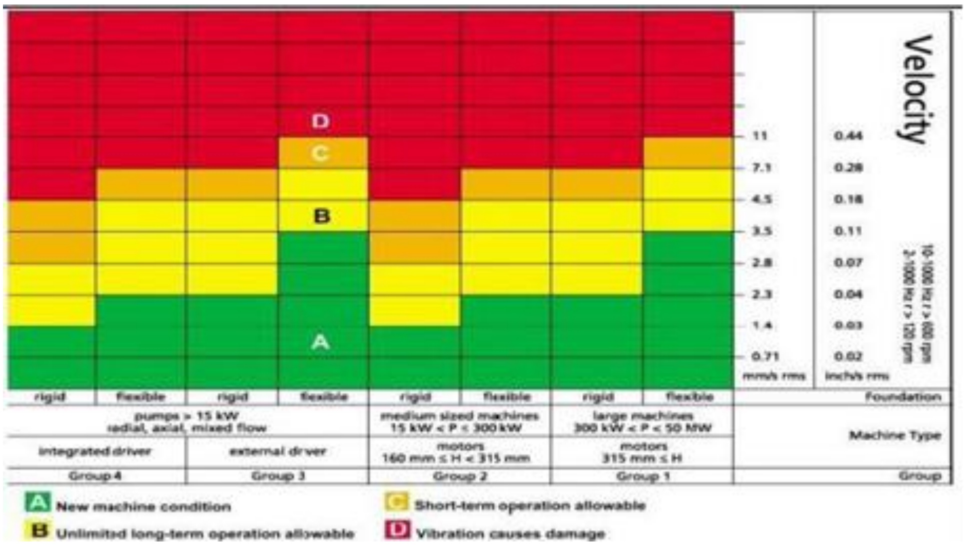


Figure 7. ISO 10816-3 standard (Jaafar A 2012).

In the ISO 10816-3 standard – ISO Guideline for Machinery Vibration Severity there are four severity levels: good (A) is like a new machine condition or a healthy machine, satisfactory (B) – Unlimited long-term operation allowable, unsatisfactory (C) – short term operation allowable, and unacceptable (D) – vibration cause damage.

C. Measurement Scheme

Measurements were made at 4 points, namely the NDE motor, DE motor, DE pump, and NDE pump, and analysis was carried out on the axial, tangential and radial axes as shown in Figure 8. Measurements were made directly by attaching the transducer to the measurement points and vibration the tester will show the results of the analysis, both in the form of text and spectrum so that they can be analyzed to determine the right treatment.

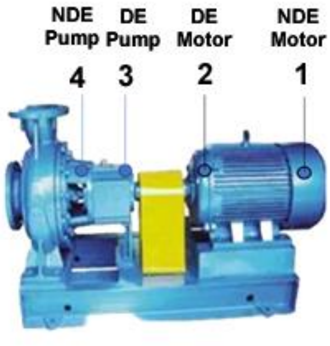


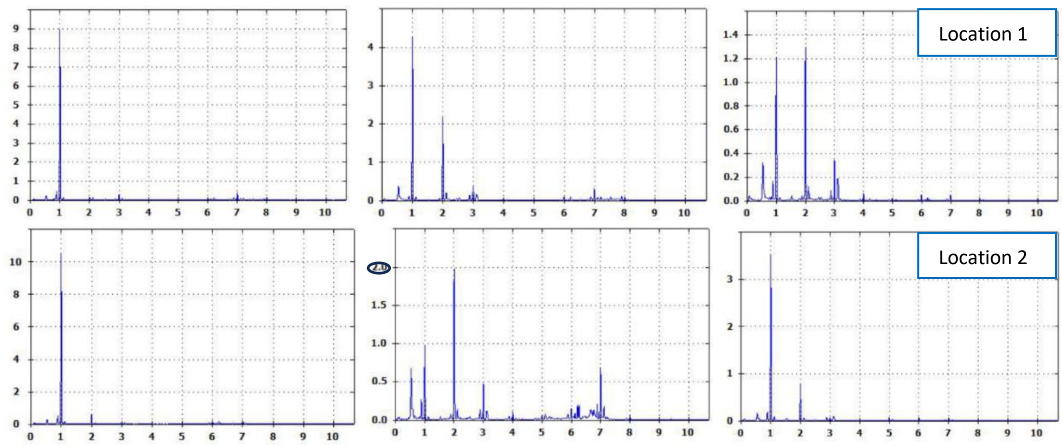
Figure 8. Vibration Measurement Scheme

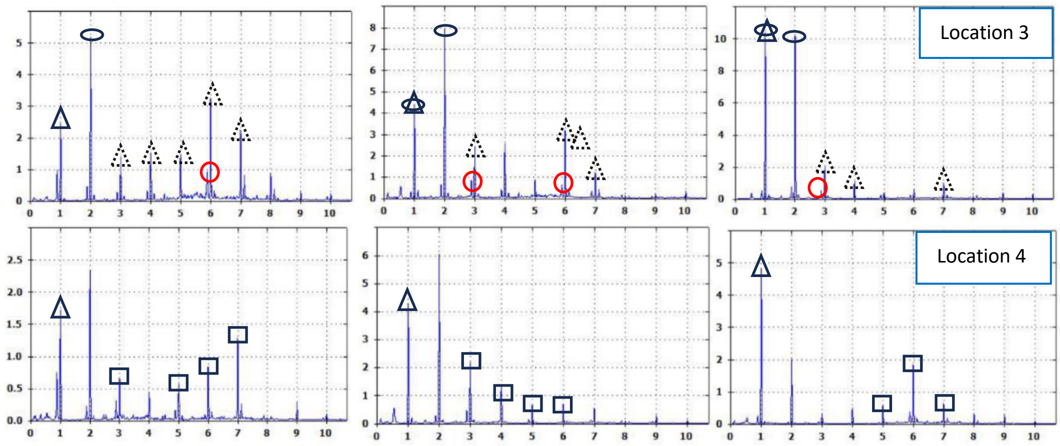
RESULTS AND DISCUSSION

From several times of monitoring indicated the same problem, with the level of damage that is not too much different. The variations in the amplitude values of vibrations that occur on the Axial (A), Tangential (T), and Radial (R) axes can be seen in table 1. From table 1, we can analyze that the vibration amplitude that occurs at locations 1 and 2 is still within the safe range to operate, while at locations 3 and 4 the vibration amplitude that occurs can cause damage. There are green colours on location 4 but its condition is near to yellow boundary.

Table 1. Vibration Amplitude based on ISO 10816-3 Standard .

Location	July 4th, 2022			August 11th, 2022			September 15th, 2022		
	A	T	R	A	T	R	A	T	R
1	0,79	0,6	0,3	0,56	0,2	0,17			
2	0,34	0,43	0,16	0,24	0,50	0,12	0,61	0,29	0,13
3	1,69	6,93	6,95	1,87	2,88	1,86	3,26	3,22	2,07
4	2,36	3,37	1,36	1,47	2,38	1,26	1,29	2,17	1,86





(Axial) (Tangensial) (Radial)

Figure 9. Vibration spectrum

Based on the characteristics of Vibration spectrum in Figure 9 (X Axis (Amplitude) unit : Orders and Y Axis (Frequency) unit : mm/sec) slack appears repeatedly at locations 3 and 4, the vibration amplitude at location 3 axis A (3A): 3.26 mm/s at order 6, 2.27/7.1.54/ 4, 1.48/5, 1.42/3. 3T: 3.22 mm/s at order 6, 2.58/4, 2.45/3,1.25/7 and 3R: 2.07mm/s at order 3, 1.09/4, 1.00 /7. indicates a mechanical looseness or bearing clearance problem ( ). For locations 3A:0.92/order 5.88, 3T:0.89/order 2.88, 0.67/5.88 and 3R:0.51/order 2.88 indicating Pump Drive End Ball Bearing Wear ( ). Peak vibration amplitude at 4A: 1.29 /order 7, 0.85/6 0.65/3.0.57/5. 4T: 2.17/order 3, 1.39/4, 0.72/6, 0.67/5 and 4R: 1.86/order 6, 0.65/7, 0.58/5. indicates a mechanical looseness or bearing clearance problem ( ). Also the normal vibration amplitude (order 1) at locations 3 and 4 shows an imbalance, 3A: 2.45/1, 3T:4.41/1, and 3R:10.45/1, 4A:1, 73/1, 4T:4.26/1, and 4R:4.83/1. So that there is an indication of a pump imbalance ( ). Whereas for 3R amplitudes: 10.45/order 1, 10.17/2, 3T:7.95/order 2, 4.41/1, and 3A:5.18/order 2, 2T:1.98/0rder 2 indicate parallel misalignment ( ).

CONCLUSION

Based on the results of the study it can be concluded that:

1. The fire pump belonging to PEM Akamigas Cepu experiences Mechanical Looseness or Bearing Clearance Problems in alarm conditions, both at the Drive End and the Free End, especially at the Drive End which is in the red area, which if operated will cause damage
2. There are indications of serious parallel misalignment, where it is only recommended to operate for a short time
3. There is an indication of pump imbalance but it can still be operated for a long time.
4. There is minor damage to Pump Drive End Ball Bearing Wear

For this reason, it is recommended to immediately carry out maintenance / repairs or consult with experts regarding the indications resulting from this study, and always monitor the increase in vibration that occurs.

ACKNOWLEDGEMENTS

We thank the PEM Akamigas Cepu through its Research and Community Service Unit for providing research funding, and also to the manager of the PEM Akamigas fire fighting unit for the permits granted, so that this research ran smoothly.

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