International Research Journal of Innovations in Engineering and Technology (IRJIET)

ISSN (online): 2581-3048

Volume 8, Issue 5, pp 1-5, May-2024

https://doi.org/10.47001/IRJIET/2024.805001

Identifying Unbalance in Forced Draft Fan Using Vibration Measurement Methods

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***Abstract* - The Forced Draft (FD) Fan is a component in a power plant that serves as a supplier of secondary air to assist combustion within the boiler. The Forced Draft Fan has a motor coupled to an impeller, where this component often experiences imbalance with very high vibration values. The imbalance can affect performance and decrease the efficiency of the Forced Fan. Special maintenance in the form of balancing is required to reduce vibration values according to ISO 10816-3 standards so that the Forced Draft Fan can operate safely. In one power plant, there was a Forced Draft Fan experiencing unbalance on the impeller side. In this study, the highest vibration value for the Forced Draft Fan was found at the MOH point, measuring 4.75 mm/s, and after balancing, the vibration value decreased to 0.82 mm/s.**

Keywords: Forced Draft Fan, Vibration Test, Unbalance, Balancing.

I. INTRODUCTION

A power plant is an industry that facilitates electrical energy for daily needs. Generally, power plants have one or more generators and rotating machines to convert mechanical energy into electrical energy[1]. Power generation units like steam power plants require dry, pressurized steam to drive turbines. One of the suppliers of air to the boiler is the Forced Draft Fan (FD Fan), which generates secondary air to assist the combustion process inside the furnace[2].The FD Fan ensures sufficient airflow to support efficient combustion.

The FD Fan is one of the rotating machines that generates vibrations, which are a function of machine dynamics, such as alignment and balancing of rotating parts, and 80% of the issues with rotating machine equipment are related to misalignment and unbalance[3]. The components of the FD Fan that generate mechanical motion often experience mechanical issues such as unbalance due to an imbalance in the mass distribution on the rotating shaft, resulting in additional centrifugal force. Several factors, such as erosion and corrosion on the blade parts can cause unbalance and high vibration[4]. Nurbanasari et al. [5]present an analysis of damage and corrosion on forced draft fan blades.

The FD Fan is driven by an electric motor and is located at the end of the boiler intake channel. The FD Fan impeller, which is directly coupled to the electric motor, can also experience imbalance because it is still within the same rotating shaft. The International Standards Organization (ISO) states that imbalance is the uneven distribution of mass along the motor's rotation axis. Balancing methods are crucial in maintaining machine operation in a safe and efficient condition[6].

Figure 1: Forced Draft Fan in a Power Plant

1.1 Vibration Signal

The vibration signal contains a lot of information about the mechanical structure of a component[7].Thus, the key to effective analysis is by decomposing this complex signal into its component frequencies. Vibration signals in their domain are classified into two categories: time domain (waveform) and frequency domain (spectrum)[8].

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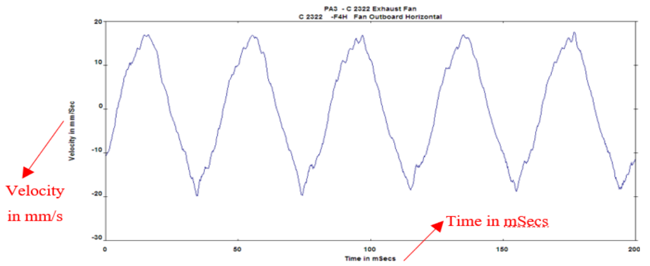

Figure 2: Waveform Signal

The waveform is a sinusoidal wave representing the relationship between amplitude and time[9]. With waveform analysis, the analysis can be done by observing the changes in the amplitude of a vibration over time in detail.

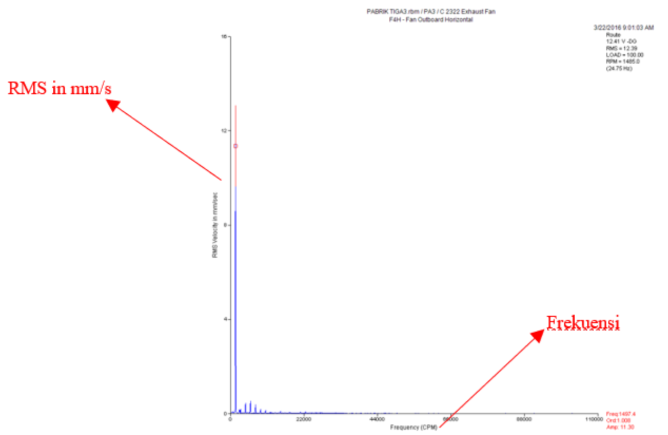

Figure 3: Spectrum Signal

The vertical axis of the Spectrum represents the amplitude of the response variable, while the horizontal axis represents the frequency (Hz, RPM). The difference in frequency and amplitude creates a collection of waves in the frequency domain, or what is referred to as the Fourier Transform method[9]. With the spectrum, failure analysis can be conducted by observing high amplitudes based on their frequencies.

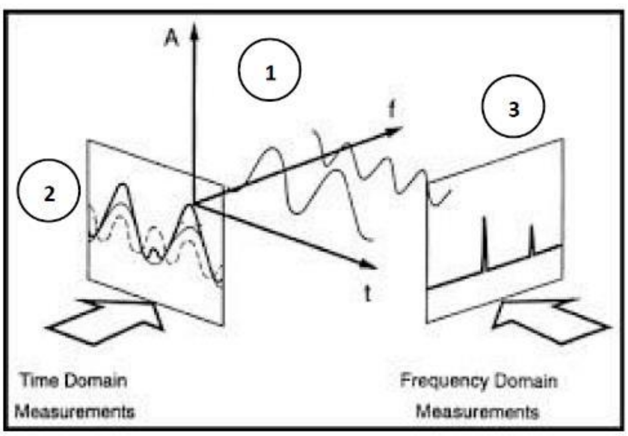

Figure 4: The Relationship between Waveform and Spectrum

II. METHODOLOGY

This study was conducted in the boiler area of the power plant, specifically on the Forced Draft Fan, which is an axial flow fan with blades (impellers) that can adjust to change position as needed. Vibration data was collected on December 20, 2023, with the motor speed of the Forced Draft Fan at 1490 rpm. Measurements were taken radially and axially at the measuring points of the Motor Outboard (MO), Motor Inboard (MI), and Fan Inboard (FI). Measurements on the Fan Onboard (FO) were not conducted because the Forced Draft Fan does not have FO.

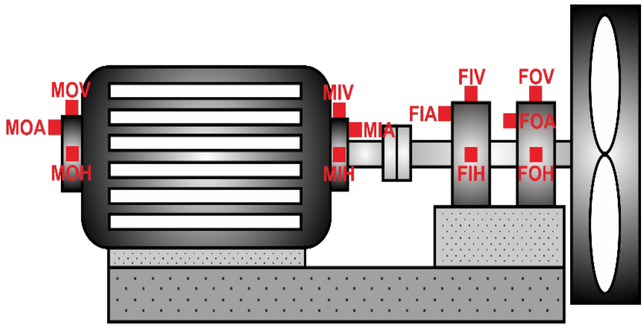

Figure 5: The Location of Measurement Points

The overall vibration data collection is conducted to determine which points experience the highest vibration values. This is crucial to identify the location of vibration excitation sources from a machine unit. After identifying the points with the highest vibration values, spectrum analysis is then performed to determine the symptoms or failures that occur. Unbalance identification is conducted by analyzing the spectrum and waveform of the vibration measurement results. Spectrum analysis is characterized by high amplitudes at 1x rpm in horizontal and vertical directions and low amplitudes at 1x rpm in the axial direction, as shown in Figure 6.

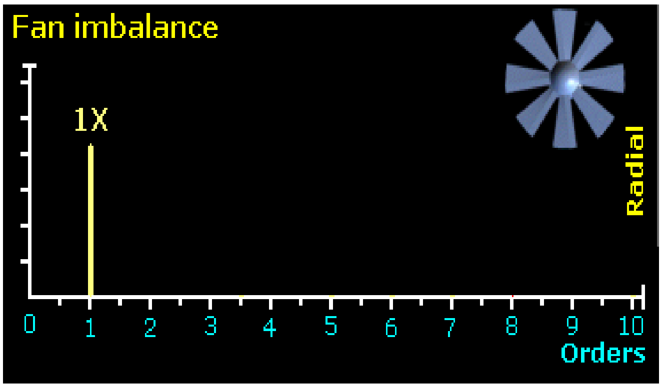

Figure 6: Spectrum with Peak Amplitude at 1x RPM

Meanwhile, the analysis of this waveform has characteristics; the waveform formed is a perfect sinusoidal shape, where the waveform shape is symmetric at every 1x shaft rotation as shown in Figure 7.

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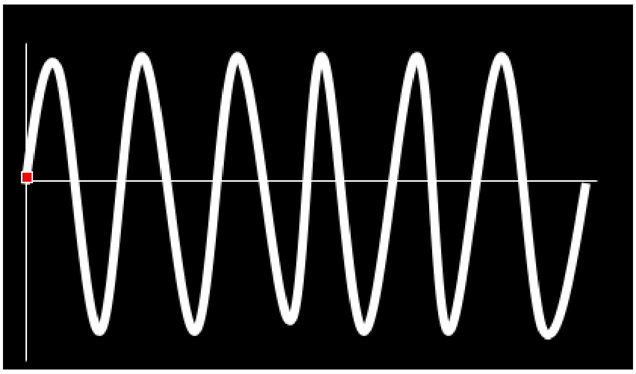

Figure 7: Waveform with Perfect Sinusoidal Shape

The vibration values obtained will be adjusted according to the Vibration Severity Chart standard ISO 10816-3 as shown in Figure 8[10]. In this study, the Forced Draft Fan is classified as a class I machine according to ISO 10816-3. Measurement points that have vibration values classified as class C have short-term operation allowable conditions that require immediate balancing action.

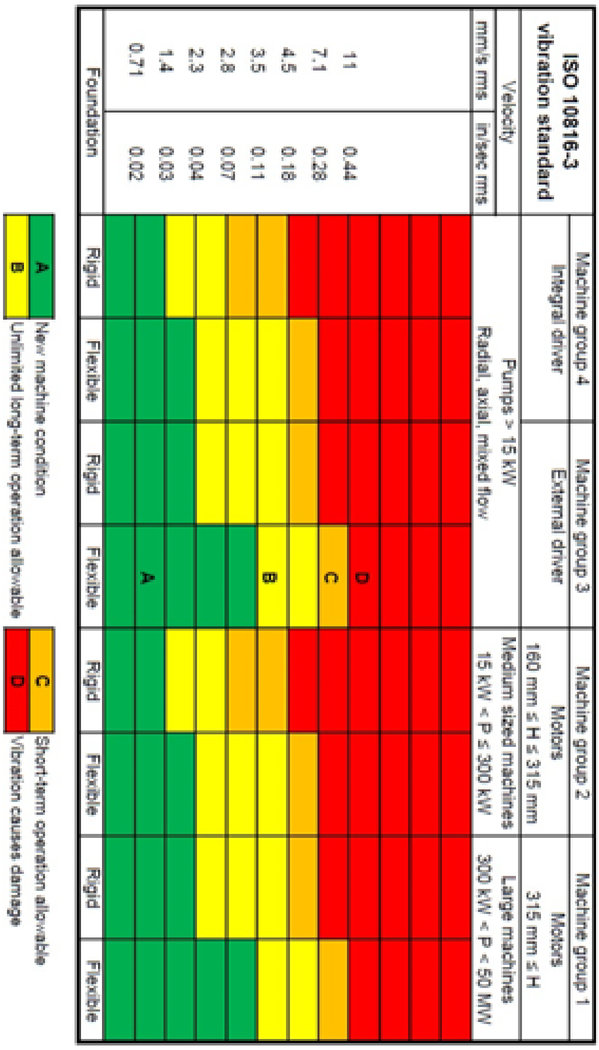

Figure 8: Vibration Severity Chart ISO 10816-03

III. RESULTS AND DISCUSSIONS

3.1 The Results of Vibration Measurements

The results of vibration measurements conducted on the Forced Draft Fan are in the form of spectrum signals and waveform signals with vibration values at each measurement point summarized in Table 1.

Table 1: Initial Vibration Measurement Results

Measurement Points		Overal Vibrasi RMS (mm/s)	ISO 10816-3 Level
1	MOH	4.75	C
	MOV	0.64	A
2	MIH	4.42	B
	MIV	0.72	A
	MIA	1.17	A
3	FIH	3.91	B
	FIV	0.73	A

3.2 Identification of Unbalance

Based on ISO 10816-3 Vibration Severity Chart, at points MOH, MIH, and FIH experience vibration in zones B and C. The highest vibration value occurs at point MOH. This value is caused by the impact of unbalance on FIH, which propagates to MOH and MIH through the transmission system connected by a single shaft. The vibration value in the FIH area indicates that the source of vibration excitation may be located at the impeller, coupling, bearing, bearing housing, and structure or foundation of the inboard fan bearing point.

The author took samples from the measurement results at the FIH point to identify the type of failure that occurred. From Figure 9, it can be seen that the horizontal measuring point is dominated by the dominant spectrum frequency of 1x RPM at order 1 and the waveform shape is sinusoidal. Referring to the reference analysis of spectrum and waveform in the basic theory, with the appearance of 1x and sinusoidal waveform shape, the damage can be identified as static unbalance.

Static unbalance occurs due to a single heavy spot on the impeller. The heavy spot causes the center of mass of the impeller to shift, so that the center of mass of the impeller is not aligned with the axis of rotation of the impeller. This causes the impeller to move outward, resulting in high amplitude and high spectrum at 1x RPM.

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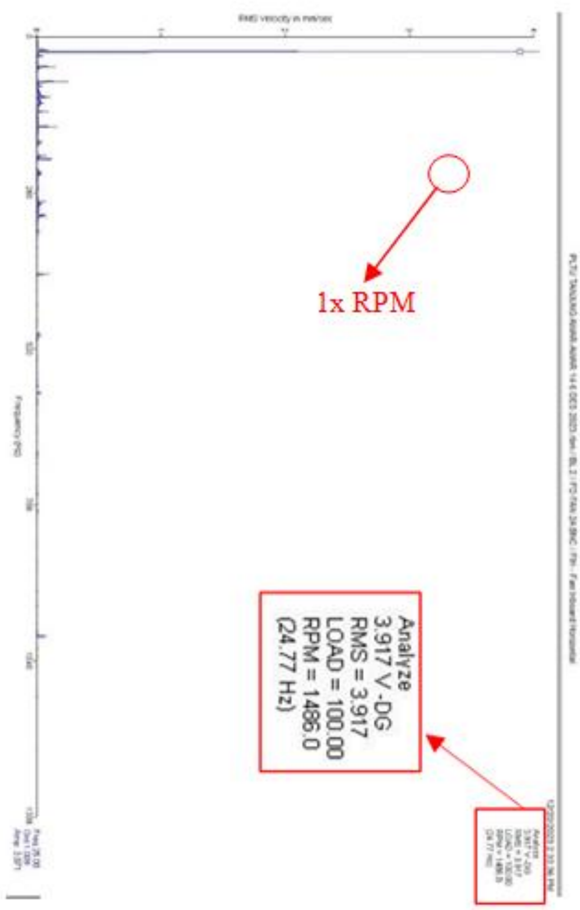
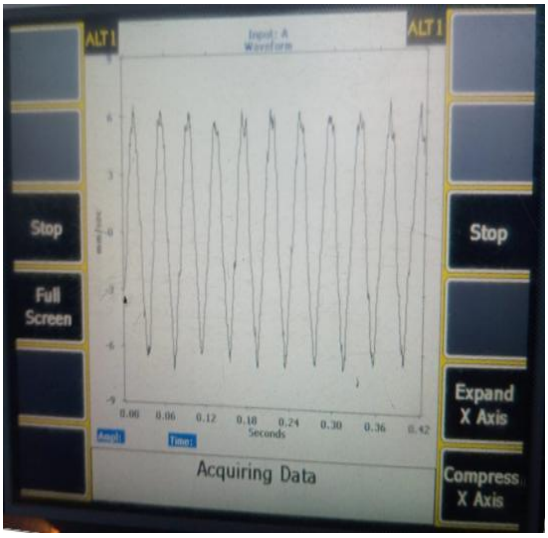


(a)



(b)

Figure 9: The Spectrum Result at FIH Point (a) and the Waveform Result at FIH Point (b)

3.3 The Result of Vibration Measurement after Balancing

Upon observing indications of static unbalance, it is necessary to perform a balancing process. After the balancing process is completed, a subsequent vibration measurement process is carried out to assess whether the vibration levels have reached a safe limit or not. The results of the post-balancing vibration measurement, as well as the comparison with the initial measurement, can be seen in Table 2.

Table 2: Comparison of RMS Values before Balancing and after Balancing

Measurement Points		The RMS value (mm/s) before balancing	The RMS value (mm/s) after balancing	Status Zone
1	MOH	4.75	0.82	C→ A
	MOV	0.64	0.38	A
2	MIH	4.42	0.75	B→ A
	MIV	0.72	0.48	A
	MIA	1.17	0.63	A
3	FIH	3.91	0.70	B→ A
	FIV	0.73	0.47	A

IV. CONCLUSION

Maintenance on machinery should always be conducted to prevent potential failures. In this case, vibration levels on the Forced Draft Fan must be regularly checked to ensure they do not affect performance. According to ISO 10816-3, short-term operation allowable conditions occur at the MOH section with the highest vibration level of 4.75 mm/s, and unlimited long-term operation allowable conditions occur at the MIH and FIH sections with values of 0.75 mm/s and 0.70 mm/s, respectively. After the balancing process, vibration levels at the MOH, MIH, FIH, and other points decreased and entered the new machine condition zone. Therefore, based on ISO 10816-3, the Forced Draft Fan can operate safely.

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Citation of this Article:

Norman Iskandar, Kusuma Febriyanto, Awaludin Aziz, Sulardjaka, "Identifying Unbalance in Forced Draft Fan Using Vibration Measurement Methods" Published in *International Research Journal of Innovations in Engineering and Technology - IRJIET*, Volume 8, Issue 5, pp 1-5, May 2024. Article DOI https://doi.org/10.47001/IRJIET/2024.805001

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