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Vibration Value of the Bearing due to Rotating Shaft Using an Accelerometer and Sensor Device

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A B S T R A C T

The bearings and rotating shaft are subjected to several repeated stresses and operates simultaneously, causing the shaft to bend at a crucial rotation. Repeated movements at regular intervals will cause vibrations. An accelerometer and Arduino sensor device are used in this experiment to measure the vibration value of the bearing caused by the rotating shaft. A miniature rotating machine manufacturing apparatus is used to replicate machine vibrations. The magnitude of the oscillations on the spinning shaft is measured by the ADXL345 accelerometer. The data from the ADXL345 is acquired by the Arduino Uno. Based on the rotation value, the amplitude, speed, acceleration, and frequency values are calculated. The radial point position had the highest values for speed, acceleration, frequency, and amplitude.

Keywords: Rotating shaft, Bearing, Vibration, Accelerometer, Arduino

1. Introduction

The shaft and bearing assembly is a rotating component connected to various elements like gears, pulleys, flywheels, cranks, and other power transmission parts. The shaft can experience bending, tensile, compressive, or torsional loads, which may act independently or in combination. When these loads work together, static stress, alternating stress, and repetitive stress occur simultaneously (Armah 2018)). The rotating shaft does not maintain a straight alignment but instead rotates in a curved manner. At a specific rotation point, the shaft's curvature reaches its peak, known as critical rotation. This phenomenon is referred to as the rotating shaft effect (Chang et al., 2025).

In the rotating components of the bearing and shaft, there is typically movement on both small and large scales due to the load on the shaft. If this movement recurs at regular intervals, it is termed vibration (Thuy et al., 2024). Vibrations can lead to damage in machine components and generate unwanted forces. Besides load-induced vibrations, shaft deflection also occurs, which is measured based on the extent of deflection and the shaft's rotation due to variations in the length and weight of the disc load mass (Rezazadeh et al., 2022). Vibration measurement is a common method for monitoring the condition of rotating machinery. Higher vibration values indicate a greater likelihood of damage to the machine (Hazwan et al., 2021). The choice of vibration parameters to measure influences the type of sensor employed, as different measurement objects require different sensors for ease of use. Eddy current sensors are typically used for measuring displacement, particularly shaft displacement relative to the bearing housing (Meng et al., 2024). The swing coil speed sensor is commonly utilized for speed measurements, while piezoelectric accelerometer sensors are generally used for acceleration measurements. The latter two sensors are often employed to measure vibrations in bearing housings (Zou et al., 2022). Research into vibration measurement remains a significant area of study due to the numerous components in moving machines. Additionally, the impact of vibration on machine performance necessitates further investigation, especially considering the various influencing factors such as material type and damper type (Katamba et al., 2024). Consequently, this study developed a prototype machine vibration measuring instrument to measure the acceleration by using the MEMS ADXL345 accelerometer sensor. Measurements are conducted using an Arduino-based system, with results processed and displayed on an LCD and PC. The Megunolink software is utilized on the PC to plot the measurement data (Khatake et al., 2019). A miniature rotating machine was also created to simulate the effects of machine rotation on the measurement outcomes.

The aim of this study is to analyze the vibration characteristics of bearing due to rotating shaft using an accelerometer and sensor device

2. Method

The design of the measurement system is depicted in a block diagram, which serves as a crucial component in the manufacturing and production process of vibration measuring instruments (see Figure 1). A mini rotary engine is used to simulate vibrations that may occur under both standard and atypical conditions. The ADXL345 accelerometer measures the intensity of vibrations generated by this mini rotary engine. The Arduino Uno acts as a signal processor, enabling data acquisition from the ADXL345 (Ferrina et al., 2022). An LCD is integrated with the Arduino to serve as a display, while

Megunolink software is utilized for data visualization on a computer. The accelerometer is mounted on the rotary engine to detect vibration amplitude based on acceleration parameters. The data obtained from this sensing process is subsequently analyzed by the microcontroller, which presents the measurement results in the form of computer graphics.

The design of the measurement system is described with a design block diagram which is the most important part of the design and manufacturing process of vibration measuring instruments (Figure 1). The miniature rotating machine simulates vibrations that occur under normal and abnormal conditions. The ADXL345 accelerometer senses the magnitude of vibrations that occur in the miniature rotating machine. Arduino Uno is a signal processor to acquire data obtained from ADXL345 (Ferrina et al., 2022 and Rohman et al., 2015). LCD is a display installed with Arduino. While Megunolink is used as data visualization software on the computer.

An accelerometer is placed on a rotating machine to sense the vibration amplitude with acceleration parameters, the sensing results are then processed by a microcontroller to then display the measurement results into a computer graph.

2.1. Tools and materials

The main tools and materials used in this study are:

1) Hardware including ADXL345 accelerometer sensor, Arduino Uno R3, 2x16 LCD Character, Transformer and others.

2) Software includes Arduino IDE, Megunolink, and PCB Wizard.

2.2. Mechanical Design

Mechanical design is the creation of a miniature rotating machine which is then used to simulate machine vibrations (see Figure 1).

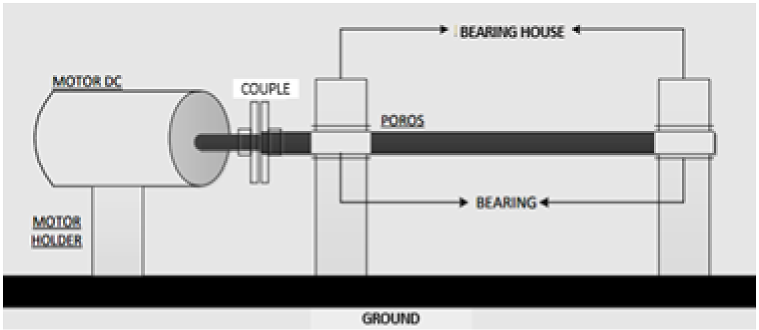


Figure 1. Design of a miniature rotating machine.

The components used in making miniature rotating machines include DC motors, bearings, bearing housings, motor holders, disturbing pendulums, couplings and bases/stands. The motor used is a 6V DC motor. The bearings used are 22 mm in outer diameter and 10 mm in inner diameter.

The tools used in this study are as follows

a. 12-volt 32-watt 6000 rpm DC motor.

b. ST 52 steel shaft

c. Motor rotation controller (PID) to vary the motor rotation.

d. Tachometer to measure the speed of the drive rotor rotation.

e. Infrared sensor

f. Camera as a documentation tool.

g. Ruler used to measure the length of the shaft, the distance of the load on the shaft.

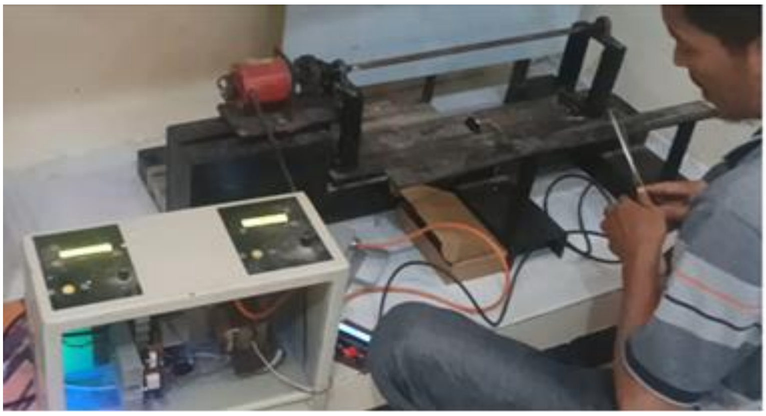
h. Grinder used to cut the shaft, solid iron and others.

i. Wrench to open and install (adjust) the bearing support shaft to adjust to the length of the shaft.

2.3. Electronic Circuit Design

In designing electronic parts, it is necessary to make a PCB (Printed Circuit Board) that can connect each electronic part into one functional circuit. The PCB making technique in this study is to draw a PCB design with the help of PCB wizard software. The results of the PCB design are then printed onto photo paper using a laser printer. The use of photo paper and a laser printer is intended therefore the results of the PCB design in the form of a wiring pattern can be attached to the CCB. After the wiring pattern is attached to the CCB, an etching process is carried out to remove unnecessary copper layers using a ferrite solution.

Then display it on the 1602-character LCD display media installed with the microcontroller. The LCD character format displays the acceleration values on the x-axis, y-axis and z-axis (Figures 2, 3 and 4) another viewer used to display data into a graph is Megunolink.



Description:

1. RPM display	5. Bearing 1
2. Frequency display.	6. Accelerometer 1
3. Deflection sensor.	7. Shaft
4. Motor	8. Accelerometer 1
	9. Bearing 2.

Figure 2 Assembly of vibration amplitude and shaft deflection measurement components.

Figure 3. RPM and deflection control assembly

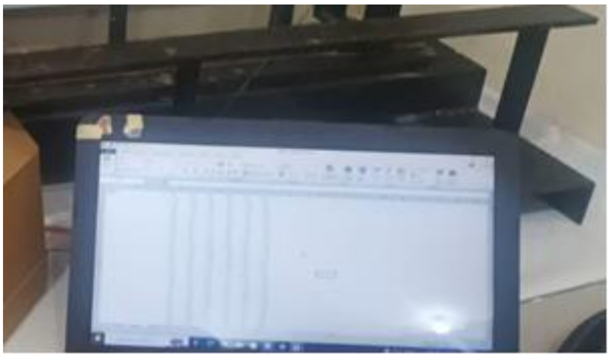


Figure 4. Displaying of acceleration data results.

3. Results And Discussion

The test results of the shaft rotation against the amplitude value are shown in Table 1. There is a small variation in the amplitude value caused by a number of RPM values. The amplitude variation ranges from 0 to 0.3 mm. This can be categorized as stable. Except for RPM rotations above 1500, the amplitude value tends to fluctuate. The farthest amplitude deviation measured from the equilibrium point in vibration. occurs in a sine wave. This is also a non-negative scalar measurement of the magnitude of the wave oscillation. Namely the back and forth movement of the shaft axis from one point to return to that point repeatedly.

The largest amplitude value is obtained at position Y1. This is because point Y1 is the closest point to the transmission bearing of the motor. Therefore, that point becomes the location of energy transfer from the motor to the transmission to then be forwarded to the shaft (Figure 5). Vibration is a motion with an alternating pattern that only occurs around equilibrium. Waves in vibration are transverse in nature which have a perpendicular propagation direction. In this experiment, the deviation points or amplitude occurs due to the rotation of the shaft at the variation of rotations per minute (RPM) against time. Meanwhile, the relationship with vibration frequency is calculated based on the vibration period.

Table 1. Experimental critical cycle test result data

Time	Axis directions					
(s)	X_1	Y_1	Z_2	X_2	Y_2	Z_2
1	0.1	-0.0	0.0	0.0	0.1	0.0
2	0.1	-0.0	0.0	0.0	0.1	0.0
3	0.1	0.0	0.0	0.0	0.1	0.0
4	0.1	0.0	0.0	-0.0	0.1	0.0
5	0.1	0.0	0.0	-0.0	0.1	0.0
6	0.2	0.2	0.0	-0.0	0.1	-0.0
7	0.2	0.2	0.0	-0.0	0.1	-0.0
8	0.0	0.0	0.0	-0.0	0.0	-0.0
9	0.0	0.0	0.0	-0.0	0.0	-0.0
10	0.0	-0.3	-0.0	-0.0	-0.1	-0.0
11	0.0	-0.3	-0.0	-0.0	-0.1	-0.0
12	0.1	-0.3	0.0	-0.0	-0.2	-0.0
13	0.1	-0.3	0.0	-0.0	-0.2	-0.0
14	0.2	-0.2	-0.1	-0.0	0.1	0.0
15	0.2	-0.2	-0.1	-0.0	0.1	0.0
16	0.2	0.2	0.1	-0.1	0.1	-0.0
17	0.2	0.2	0.1	-0.1	0.1	-0.0
18	0.2	0.2	0.1	-0.1	0.1	-0.0
19	0.2	0.1	-0.0	-0.0	0.1	0.0
20	0.2	0.1	-0.0	-0.0	0.1	0.0
21	0.3	-0.0	0.0	-0.1	0.1	-0.1
22	0.3	-0.0	0.0	-0.1	0.1	-0.1
23	0.1	-0.0	-0.0	0.1	0.1	0.0
24	0.1	-0.0	-0.0	0.1	0.1	0.0
25	-0.1	0.1	0.0	-0.1	-0.1	-0.0
26	-0.1	0.1	0.0	-0.1	-0.1	-0.0

27	0.1	0.2	0.0	-0.0	-0.1	0.0
28	0.1	0.2	0.0	-0.0	-0.1	0.0
29	0.1	0.3	0.1	-0.0	-0.0	-0.0
30	0.1	0.3	0.1	-0.0	-0.0	-0.0
31	0.1	0.1	-0.0	-0.0	0.1	-0.0
32	0.1	0.1	-0.0	-0.0	0.1	-0.0
33	0.0	-0.0	0.0	-0.0	0.1	0.0
34	0.0	-0.0	0.0	-0.0	0.1	0.0
35	0.0	-0.0	0.0	-0.0	0.1	0.0
36	0.0	0.0	0.0	-0.0	0.1	-0.0
37	0.0	0.0	0.0	-0.0	0.1	-0.0

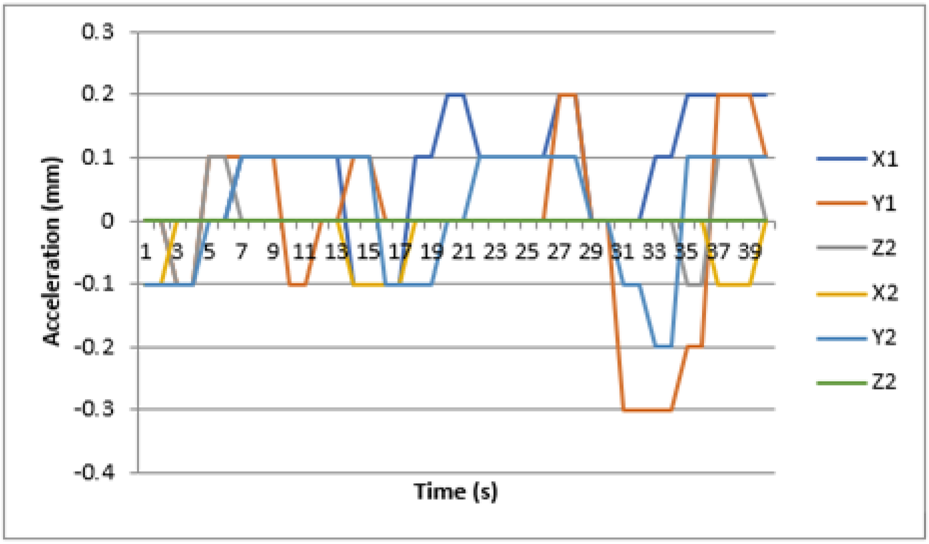


Figure 5. Relationship between amplitude and time at two bearings in positions x, y, z with a motor speed of 1400 rpm.

From the results of the vibration signal analysis, it can be concluded that the ADXL345 Accelerometer spectrum of normal bearing conditions and critical rotations gives different characteristics (see Table 2 and Table 3). In normal bearing conditions, the amplitude value tends to be stable and only peaks are seen at the primary frequency (1x running speed), while in critical rotation conditions, the amplitude value tends to vary in the frequency range of 18 - 35 Hz (Figure 6 dan Figure 7).

From the critical rotation test using a deflection distance measuring sensor, the test result data was obtained with 3 variations of shaft lengths of 40 cm, 50 cm, and 60 cm. and the position of the left, middle and right disk masses with a fixed mass of 500 kg. Based on the experiment, the results of the critical rotation and deflection were obtained at maximum rotation, namely when the shaft reached the highest deflection.

Table 2 Values of bearing vibration

Rotations (rpm)	**v (m/s)**	**a (m/s^2)**	**X (g)**	**f (Hz)**
600	3,31	0,12	0,325	33,43
740	3,30	0,13	0,350	34,59
980	3,31	0,46	0,400	37,31
1500	3,36	1,27	0,67	30,71

Table 3 Frequencies of vibration according to the rotation

Frequency	**600**	**740**	**980**	**1500**

(Hz)	**(rpm)**	**(rpm)**	**(rpm)**	**(rpm)**
1	19,04	19,04	19,04	49.75
2	36,15	37,31	33,81	24.88
3	33,43	34,59	37,31	30.71

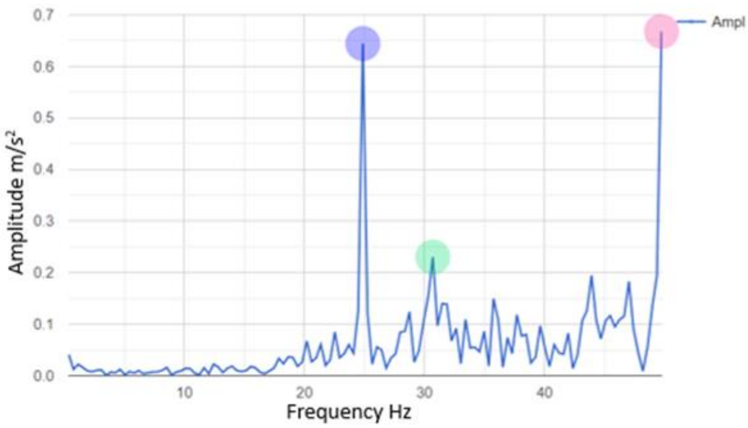


Figure 6. Amplitudes of vibration in rotation of 1500 rpm

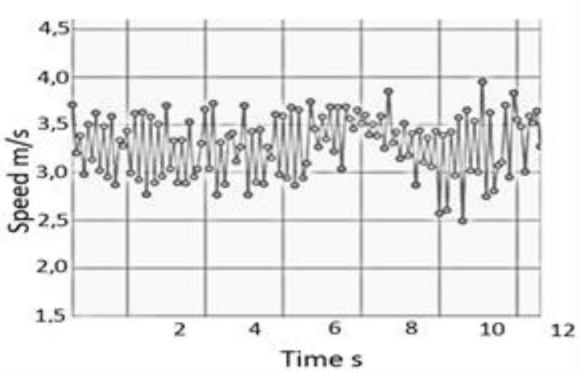


Figure 7. Speed of vibration at rotation of 1500 rpm (max 4,7; average 3,36; min 2,5)

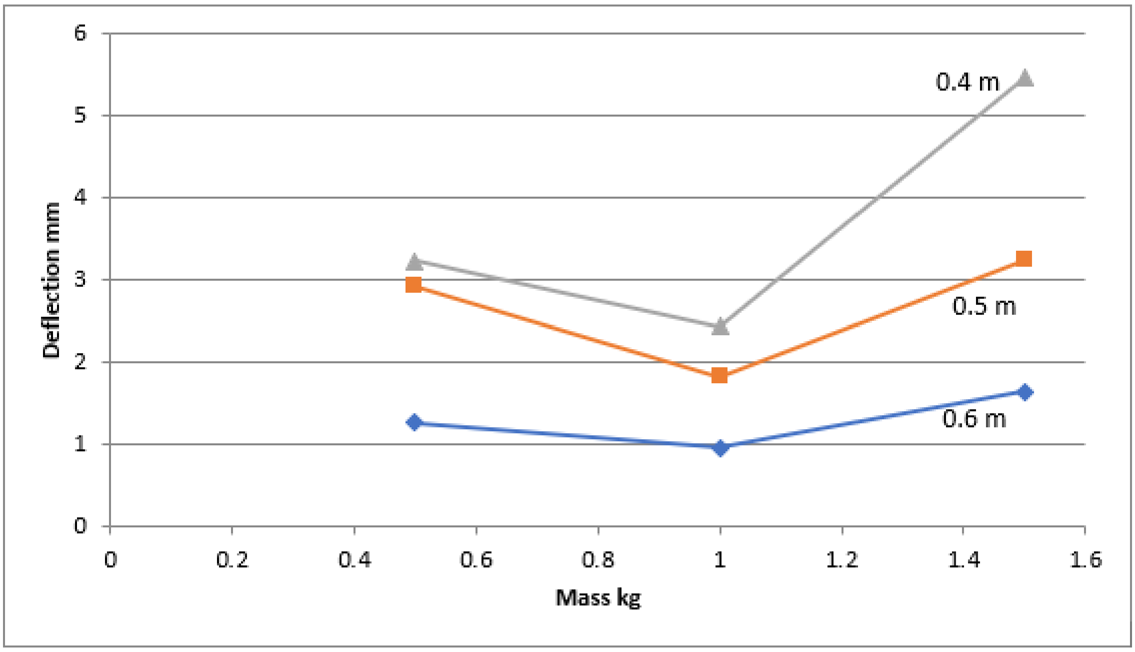


Figure 8. Graph of the effect of disk mass on the experimental deflection value.

The length of the shaft affects the deflection that occurs. From the masses installed on the left, middle and right sides of the shaft, different deflection values are obtained according to the position of the mass.

The critical rotation value that occurs at a shaft length of 0.4 m, 0.5 m and 0.6 m with the left, middle and right mass positions, the largest rotation value is seen at a shaft length of 0.4 m with the right and left mass positions with a maximum rotation of 2400 rpm (Figure 8). For the same shaft length with the mass position right in the middle of the shaft, the maximum rotation is 2000 rpm. This is due to the short shaft so that the left and right mass positions are not different because the support distance is the same. While the largest rotation value at a shaft length of 0.5 m with the right and left mass positions with a maximum rotation of 2200 rpm, for the same shaft length with the mass position right in the middle of the shaft, the maximum rotation is 1800 rpm. Meanwhile, at the largest rotation value at a shaft length of 0.6 m with the mass position on the right and left with a maximum rotation of 2000 rpm, for the same shaft length with the mass position right in the middle of the shaft. This is caused by the short shaft therefore that the position of the left and right masses is not different because the distance of the support is the same. This is caused by the short shaft so that the position of the left and right masses is not different because the distance of the support is the same. When using the shaft repeatedly, the shaft is not completely straight, while for the short shaft, a greater rotation is obtained compared to the long shaft.

If the deflection that occurs is smaller, then the natural frequency that occurs will be greater. Because deflection is inversely proportional to the natural frequency. Therefore, the critical rotation that occurs on a short shaft is large because the critical rotation is directly proportional to its natural frequency. Likewise, the critical rotation will be smaller if the shaft is longer. The whirling phenomenon will be different again when the disk that functions as a weighting mass is varied in its mass position.

The lowest deflection was also obtained at a shaft length of 0.4 m with a disk mass of 1 kg, the deflection obtained was 0.96 mm, at a mass of 0.5 kg, a deflection value of 1.27 mm was obtained and the highest was 1.64 mm at a disk mass of 1.5 kg. While at a shaft length of 0.5 m with a load of 0.5 kg, a deflection value of 2.92 mm was obtained and 1 kg obtained a deflection value of 1.82 mm, 1.5 kg obtained a deflection value of 3.24 mm and the largest deflection at a disk mass of 1.5 kg of 3.24 mm. At a length of 0.6 m, the largest deflection was obtained at a disk mass of 1.5 kg of 5.45 mm, while for disk masses of 0.5 kg and 1 kg, a deflection of 3.22 mm and 2.43 mm were obtained. This phenomenon shows that the deflection that occurs increases along with the addition of mass as a weight and due to the influence of the increasing length of the shaft.

From the relationship between rotation and disk mass theoretically obtained the smallest rotation of 2289 rpm at a shaft length of 0.6 m with a mass of 1.5 kg, for a mass of 1 kg and 1.5 kg obtained rotation of 2441 rpm and 2629 rpm in this case there is an increase due to the variation of the mass given is getting smaller. While for a length of 0.5 m with a mass of 0.5 kg the rotation is obtained 3596 rpm, for a mass of 1 kg obtained rotation of 3321 rpm, and for a mass of 1.5 kg obtained rotation of 3100 rpm. And for a length of 0.4 m obtained the largest rotation of 3463 at a mass of 0.5 kg, and for a mass of 1 kg and 1.5 kg obtained rotation of 2625 rpm and 1918 rpm. This rotation value is obtained based on the formula theoretically.

4. Conclusions

There is a small variation in the amplitude value generated at a number of RPM values. The amplitude variation ranges from 0 to 0.3 mm. This can be categorized as stable. Except at RPM rotations above 1500, the acceleration values tend to fluctuate. The largest acceleration value is obtained at the radial point Y1 position. This is because point Y1 is the closest point to the transmission bearing from the motor. Therefore, that point becomes the location of energy transfer from the motor to the transmission to then be forwarded to the shaft. From the critical rotation test using a deflection distance measuring sensor, the results of the critical rotation and deflection at maximum rotation are obtained, namely when the shaft reaches the highest deflection. The length of the shaft affects the deflection that occurs. the masses installed on the left, middle and right sides of the shaft get different deflection values according to the position of the mass. The largest critical rotation value at a shaft length of 0.4 m with the mass position on the right and left with a maximum rotation of 2400 rpm. for the same shaft length with the mass position right in the middle of the shaft, the maximum rotation is 1800 rpm.

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Vibration measurement

The process of determining the level of vibration in an object or environment. This process is important to ensure safety and comfort, as well as to monitor the condition of equipment and structures. Vibration can be measured using various tools such as vibration meters, seismometers, or other vibration measuring devices.

ADXL345

Consists of 3-axis (X, Y, and Z) digital accelerometer used to measure linear acceleration. This sensor has high resolution and wide measuring range, and is able to detect very small vibrations, making it suitable for a variety of applications, including mobile devices and navigation systems.

Accelerometer

The device that functions to measure the acceleration of an object. This device works on the principle of mass attached to a spring, and when the object experiences acceleration, the mass will move. This mass displacement is then measured and converted into useful units.

Shaft testing machine

Also known as a shaft critical rotation testing machine, is a tool used to test and analyze the performance of a shaft, especially in terms of its critical rotation. This tool is essential for determining the safe operating limits of rotating machinery and preventing excessive vibration.

Drive shaft acceleration

The rate of change of vibration velocity on a drive shaft. Shaft vibration can be caused by a variety of factors, such as imbalance, improper U-joints, or dynamic vibration. Vibration acceleration is usually measured in m/s^2, in/sec^2 or "G" (gravitational acceleration).

Critical shaft speed

The rotational speed of the shaft at which maximum deflection or bending occurs, and results in large vibrations or "whirling shaft". This is the speed that must be avoided when operating the machine because it can cause damage or failure.

References

Armah, S. K. (2018). Preliminary Design of a Power Transmission Shaft under Fatigue Loading Using ASME Code. *American Journal of Engineering and Applied Sciences*, 11(1), 227-244.

Chang X, Liu J, Yan X, Sun F, Zhu H, Wang C. (2025) Experimental Study on the Effects of Controllable Parameters on the Healthy Operation of SF-2A Material Water-Lubricated Stern Bearing in Multi-Point Ultra-Long Shaft Systems of Ships. *Journal of Marine Science and Engineering, 13*(1):14.

Thuy Chu, Tan Nguyen, Hyunsang Yoo, Jihoon Wang (2024) A review of vibration analysis and its applications, Heliyon, *10* (5)

Rezazadeh, N., De Luca, A., Lamanna, G., & Caputo, F. (2022). Diagnosing and Balancing Approaches of Bowed Rotating Systems*: A Review. Applied Sciences,* 12(18), 9157

Hazwan, M.G, and Wan, R., (2021), Vibration Analysis for Machine Monitoring and Diagnosis: *A Systematic Review, Shock and Vibration*.

Meng, Z., Liu, Y., Chen, Y., Cheng, Z., Feng, G., Zhang, H., Gao, N., & Zhang, Z. (2024). Development of an On-Shaft Vibration Sensing Module for Machine Wearable Rotor Imbalance Monitoring. Electronics, *13*(13), 2466.

Zou, Y., Sun, M., Xu, W., Zhao, X., Du, T., Sun, P., & Xu, M. (2022). Advances in Marine Self-Powered Vibration Sensor Based on Triboelectric Nanogenerator. *Journal of Marine Science and Engineering*, *10*(10), 1348.

Katamba M, Aimé L.E., Moise, A.U., Caterina, C.G., Pappalettera (2024) Wear monitoring based on vibration measurement during machining: An application of FDM and EMD, Measurement: Sensors, 32, 101051

Khatake P., and Admane A.A. (2019) Vibration Monitoring and Analysis In Machining, *International Journal of Innovations in Engineering Research and Technology*, 2019, 1-4.

Hasibuzzaman, M., Shufian, A., Kabir, R.S., (2020) Vibration Measurement & Analysis Using Arduino Based Accelerometer, Conference: 2020 IEEE Region 10 Symposium (TENSYMP)At: Dhaka, Bangladesh

Mireia, B.M., Matthew, R.P., and Stephen T.H., (2023), Digitisation of a modular plug and play 3D printed continuous flow system for chemical synthesis, Digital Discovery, *6*(2), 1797-1805

Ferrina, Q., Ratna Sulistiyanti, S., and Junaidi (2022). Results of ADXL345 accelerometer sensor calibration testing, *Journal of Physics Theory and Applications*, 10(2), 187–196.

Rohman, A. (2015) Design and construction of vibration measuring instruments using micro electro mechanical system sensors" (Mems) Accelerometer Edu Electrical Journal, 4(1), 8-16.