Vibrations signature analysis of whirling shaft of varying diameters operated at varying speeds.

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Abstract - Vibration is a mechanical phenomenon in which oscillation occurs about equilibrium points. It is a displacement or movement in one direction and then back again in the opposite direction. For example, the musical Instruments that may be plucked. The passage or Era of time vibration has become major issue for the machinery and industries. Everyone knows that the vibration has some merits and demerits. But in modern technology age we can never eliminate whole vibrations in a machine. Some specific amount of vibration depending upon the quantity always remains there. This paper tries to focus on the analysis of the effects produced on the whirling shaft of different diameters while running at the different speeds. The objective of the study is to find the effect of different diameters rotating at different speeds on the amplitude and natural frequency of the shaft. Also forced vibration analysis of the shaft is done. Some parameters are also studied that are responsible for the failure of the system before breakdown, and the effect of the resonance frequency of the shaft. Using the vibscanner instrument a spectrograph is produced to study the effects on amplitude and natural frequency of the whirling shaft. vibration factors on it. This spectrograph is transferred to computer with the help of OMNITREND to better analyze the data.

1. INTRODUCTION

Vibration is a mechanical phenomenon in which oscillation occurs about equilibrium points. It may be noticed that any motion that repeats itself after an interval of time is known as vibration or oscillation. It is a displacement or movement in one direction and then back again in the opposite direction. For example, the musical Instruments that may be plucked. Mostly the energy can be put into the system through an applied force; either can be internal & external. The forces may be instantaneous, impulse & continuous. In the machine this type of energy can be divided from the process. This reduced the machine efficiency & may also result in damage to the machine components or parts.

In today’s era vibration is the major problems for the rotating machineries such as turbines, compressors, crushers etc. These problems occur more frequently when the rotating speeds increase and reach near the corresponding resonance frequencies of the shaft. Due to this, severe stresses are developed in the bearings which cause the failure of the system. The main focus of this investigation is to study the vibration effect on the rotating shaft using the Vibscanner instrument. We are also interested to determine the parameters causing the breakdown of the rotating shafts. The present study is the analysis carried out with the theoretical and experimental procedures.

2. EXPERIMENTAL SETUP AND PROCEDURE

Experimental analysis plays most important role in the research work. Experimental approach is being carried out and justify the theoretical and experimental analysis or by using different techniques. Experimental setup is being be made to measure the natural frequency and amplitude of the different diameter shafts.
2.1 THEORETICAL AND EXPERIMENTAL MODEL

To study the dynamic characteristics of the specimens including parameter like natural frequencies and amplitudes of the shaft various combinations of shaft diameter and rotating speeds are made. The lengths of all the shafts are taken equal. For changing speeds of the rotating shafts, speed variator has been taken into consideration.

**Figure 1.** Schematic diagram depicting whirling shafts of various diameters operated on different RPMs.

The whirling shafts have been made of Mild steel (MS) and have different diameters (4.5, 6.5, 7.5 mm) taken in the study. For the analysis of vibrations these shafts are run at two different speeds of 600 and 800 RPM. The data was captured from the different ends of the shaft i.e. “Drive end and Non-drive end” of the shaft. Measurement of signal was done at three different directions of the shaft i.e. “horizontal, vertical and axial”. Data was collected with the help of an accelerometer which is further connected with a portable data acquisition instrument known as VIBSCANNAR. The data collected in VIBSCANNAR is transferred to the computer with the help of a software known as OMNITREND. The Fig. 2 (a, b, c) explains the experimental setup of the whirling shaft at Drive End in three different directions i.e. Vertical, Horizontal and Axial.

**Figure 2.** Experimental setup of the shaft connecting accelerometer in three different directions i.e. (a) Vertical (b) Horizontal (c) Axial at the Drive End
The Fig. 3 (a, b, c) explains the experimental setup of the whirling shaft at Non-Drive End in three different directions i.e. Vertical, Horizontal and Axial.

![Experimental setup of the shaft connecting accelerometer at different locations](image)

**Figure 3.** Experimental setup of the shaft connecting accelerometer at the different locations i.e. (a) Vertical (b) Horizontal (c) Axial at the Non-Drive End

Frequency response functions (FRFs) were obtained using Vibscanner and were processed using OMNITREND software to identify and compare amplitudes of the shafts at different speeds.

3. **ANALYSIS PROCEDURE AND DISCUSSION**

The vibration analysis can be conducted on the test specimen to obtain the dynamic characteristic that may be natural frequency of the whirling shaft. First natural frequency of the shaft can be measured in the first mode only. The dynamic parameters can be measured with the help of accelerometer. The accelerometer is placed at the “drive and non-drive end” of the shaft and connected with the Vibscanner with the help of cables. Accelerometer can be used to measure the vertical, horizontal and axial displacement of the shaft. Now we can determine the amplitude and frequency of the shaft with the help of spectrograph.

We have made various graphs for the analysis of the whirling shaft while running in motion. The study shows how the whirling shaft of different diameters and running at different speed effects the system. These graphs have been shown for the analysis and comparison of the dynamic parameters of the shaft. There will be different amplitude and frequency level graphs made for the study to find the vibration factors on the running condition of the whirling shaft. Now we will show some part of analysis from the various mode of whirling shaft experimental studies at different running speed (600 and 800 rpm), directional ends (drive and non-drive ends) and directions (Horizontal, Vertical and Axial) in the system.

3.1 **ANALYSIS OF DRIVE END OF THE WHIRLING SHAFT WITH VARYING SPEED (600 AND 800 RPM)**

3.1.1 **DRIVE END OF THE SHAFT WITH 600 RPM**

| SHAFT DIA (MM) | SHAFT AMPLITUDE (MM/S) | TYPE | RPM | MEASUREMENT DIRECTION | MEASUREMENT LOCATION |
|----------------|------------------------|------|-----|------------------------|----------------------|
| 4.5            | 8.4                    | SET 1 (DE) | 600 | VERTICAL              | DRIVE END            |
| 6.5            | 7.8                    | SET 2 (DE) | 600 | VERTICAL              | DRIVE END            |
| 7.5            | 8.07                   | SET 3 (DE) | 600 | VERTICAL              | DRIVE END            |

**Figure 4.** Amplitude comparison of whirling shaft with varying diameters at 600 RPM at Drive End
While analyzing the study of whirling shaft with varying diameters as the running speed increased more fluctuations were observed in the system. More vibration amplitudes were noticed in the vertical direction of the shaft as compared to horizontal and axial directions at the drive end of the shaft because of the centrifugal forces developed in running condition. As we increased the diameter of the shaft there was further increase in amplitude of the vibrations of the shaft. Amazingly the amplitude in the vertical direction of the drive end of the shaft had seen more unbalanced in the running condition.

3.1.2 DRIVE END OF THE SHAFT WITH 800 RPM

![Figure 5](image1.png)

**Figure 5.** Amplitude comparison of whirling shaft with varying diameters at 800 RPM at Drive End

As we increasing the running speed of the shaft at the drive end, there will be suddenly increase in the amplitude of the shaft as we increase the diameter of the shaft. Here more fluctuations can be observing in the vertical directions of the shaft. This can be due to the centrifugal forces induced on the coupling and reduces the running motion of the shaft. In the running condition of the system there will be more unbalanced forces acting on the shaft to produce more vibrations at a particular area of the shaft as the speed of the shaft increases.

3.2 ANALYSIS OF NON-DRIVE END OF THE WHIRLING SHAFT WITH VARYING SPEED (600 AND 800 RPM)

3.2.1 NON-DRIVE END OF THE SHAFT WITH 600 RPM

![Figure 6](image2.png)

**Figure 6.** Amplitude comparison of whirling shaft with varying diameters at 600 RPM at Non-Drive End

After analyzing the spectrographs of amplitudes of the whirling shaft in the non-drive end while in the running mode of the system it was seen that amplitude of the shaft in horizontal direction at the non-drive end was more critical. This might be due to the coupling forces and eccentricity problems arisen to this end of the shaft to reduce the shaft motion in the system. If the center of mass attached to the shaft has been disturbed, then shaft would also be unstable and will experience more vibrations in the system.
3.2.2 NON-DRIVE END OF THE SHAFT WITH 800 RPM:

Now at the non-drive end of the shaft, there will be the horizontal direction which was unstable in nature. Again, this might be due to the coupling forces and eccentricity problems induced in the shaft to reduce the running motion of the shaft. Sometimes the higher running speeds of the shaft which can induce the whirl in the shaft that becomes one of the reasons of breakdown. Here, axial direction has also unbalanced in the shaft because of resonate forces that can be attack at the system to reduce the stability.

4. CONCLUSION

By the study of various literature reviews, it has been concluded that, this method of acquiring vibration data with the help of VIBSCANNER and then analyzing its spectrographs is very latest as compared to ancient times when these equipment’s were not available for vibration analysis of the whirling shafts and other rotating machinery. This is a modern technique to record the vibration characteristics of stationary as well as rotating parts of the system. By knowing the amplitude and natural frequency of the shaft to reduce the failure on the rotating shaft before the break down occurs on it. This can be helpful for the rotating parts of various machines or instruments which are running at very high speed. Now, this can be easily judged that up to which diameter and rotating speed the system is running safely with which a major breakdown can be prevented to occur. As we analyze the various spectrographs of amplitudes and frequencies of the shaft with changing parameters in the running condition of the system to compare its values. So, from the above study some facts can be concluded in the study of vibrations which might be very helpful for condition monitoring of rotating parts of machines and other mechanical installations. These may be giving as below

1.) As we increase the speed and diameter of the whirling shaft, there will be direct increase in the amplitude of shaft while the system is in the running condition.
2.) Whirling shaft has the maximum amplitude in vertical direction of the drive end, while we run the system with varying speeds of 600 and 800 rpm in the system.
3.) Whirling shaft has also the maximum amplitude in horizontal direction of the non-drive end, while we run the system with varying speeds of 600 and 800 rpm in the system.
4.) The maximum amplitude level of the whirling shaft occurs for a shaft diameter of 6.5 mm shaft at both drive and non-drive end of the shaft.

5. FUTURE SCOPE

After this study on the whirling shaft various aspects can be introduced for the study to reduce or minimize the vibration and break down in the system. These may be
1. Using the different material (Aluminum, mild steel, Stainless steel, bronze etc.) shaft for the comparison of the whirling shaft with different diameters.
2. Using the Ansys software to determine the static and dynamic load on it and also check the vibration factors on the shaft.
3. Using the MATLAB to create the mode shapes of the whirling shaft while in the running condition.

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