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Analysis of Defective Bearings

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Abstract: ***Rolling element bearings are widely used as low friction joints between rotating machine components. A small defect either on raceway or the ball may occur while installation or any other process should be detected. If not detected in time, the defect forms a fatigue and increases upon working, decreasing the life time of bearing and leads to malfunctioning of the machine components. This research work is mainly focused on the frequency of vibrations produced by the bearings with different faults and gives the comparison between vibrational frequency of different faulty bearings and healthy bearing. The results of this experiment are interpreted to shoot out the defect in the bearing, which is helpful in finding the fault in the bearing element without dismantling the machine with reference to the frequency graphs.***

Keywords: ***If Not Detected In Time, the Defect Forms A Fatigue And Increases Upon Working,***

I. INTRODUCTION

Bearing components play an essential part in most of the industrial rotating and transport machinery applications. Detection of faults at an early stage helps us avoid malfunctioning and breakdown of machine components [1-5]. Monitoring the current status of the bearing without disassembling the machine components saves power, time and resources. The rolling element bearing fails due to errors in manufacturing, assembly, and loading operations. Improper working environment like without lubrication or high speed operations for a long time leads to fatigue formation. The discontinuity formed develop upon further working and if not detected leads to sudden breakdown of the component. Generally, the vibrations produced by a healthy bearing may not be low. When the rolling elements like balls in ball bearing pass through a discontinuity, it produces a higher frequency [6-8]. The frequencies produced vary with the size of discontinuity and location of the fault. So, with reference of the vibrational frequencies, the location and the size of fault on them can be identified without disassembling the component.

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II. EXPERIMENTATION

Initially, a fault is developed in the bearing using CNC wire cut machine. The defects are made on inner, outer races and on the balls. Afterwards the faulty bearings are fixed to the experimental rotor.

Fig (1) shows the CNC wire cut machine is used to produce faults on both inner and outer raceway of the ball bearing.

Figure 1. CNC Wire Cut Machine

A Laser Doppler Vibrometer (LDV) a scientific instrument that is used to make non-contact vibration measurements of a surface. The laser beam from the LDV is directed at the surface of interest, and the vibration amplitude and frequency are extracted from the Doppler shift of the reflected laser beam frequency due to the motion of the surface. The output of an LDV is generally a continuous analog voltage that is directly proportional to the target velocity component along the direction of the laser beam.

Initially, the motor is fixed to the metallic base. Bearing fixers onto the base. Small shaft having Oldham coupling into the motor. Main shaft attached to the small shaft using Oldham coupling. The main shaft runs through 2 bearing fixers which are fixed to the base of the test rig. Here we make use of clips which affix the bearings into the bearing carriers very firmly.

A normal faultless bearing is fixed into the carrier closer to the motor. This bearing is made as our reference to which the vibrational analysis of the fault bearing is compared. The faulty bearings are fixed into the carrier on the farther end of the shaft. The 2 discs are keyed to the shaft. We attach silver strips to both the bearing carrier. These are stuck onto the bearing fixers individually at two separate instants. These are the ones on which laser from the laser Doppler vibrometer is focused exactly on its center.

We then setup the laser vibrometer which emits laser at a certain frequency onto the bearing and again receives the reflected waves. This setup is connected to a DAQ which shows the time displacement graphs. The laser vibrometer machine rests in a three legged stand. Height of the stand is varied in such a way that the final height satisfies the condition of perpendicularity between laser and the bearing fixers.

After completely fixing the equipment, the test rig is placed in such a way that the strips are exactly perpendicular to the laser vibrometer. Perpendicularity is to be ensured because the bearings vibration is along the direction of the main shaft and also the strip is stuck parallel to the bearings vibrations.

Laser must be focused onto the center of the rectangular strip. This can be made sure by observing the readings on the laser vibrometer screen. The variance of readings from “1” to “10” in an increasing order can be considered to be as increasing order of proximity towards the center of the strip. The speeds of the motor at the initial running speed of 500rpm and increased up to 2500rpm, by 500 rpm steps. The time displacement graphs of both the normal and fault bearings are recorded at each of these separate speeds.

Fig. 2 shows the experimental setup of the rotor bearing system during the experimentation.

Figure 2. Experimentation on a Test Rig

The basic characteristics like ball passing frequency of outer and inner races, balls etc are calculated analytically to validate the readings at different speeds as shown in the Table.1.

Table. 1 Calculations of the Bearing Characteristics (SKF bearing)

SPEED (rpm)	BPFO (rpm)	BPFI (rpm)	FTF (rpm)	BSF (rpm)
500	1285	2215	185	880
1000	2570	4430	370	1760
1500	3855	6645	555	264
2000	5140	8860	740	3520
2500	6425	11075	925	4400
3000	7710	13290	1110	5280

The bearings with different faults are taken in the experimentation and the supporting bearing at the left rotor was changed with different faulty bearings. Initially, the bearing with no faults was installed and the response was taken at different speeds from 500 to 2500 at 500 rpm speed steps. Then slowly the bearing was changed and the frequency responses are recorded at left rotor by charging the left bearing.

III. RESULTS AND DISCUSSIONS

Fig. 3 shows the frequency response at left bearing at a speed of 500 rpm with ball fault, inner race fault, outer race fault, all faults and no fault bearings.(x-axis-time,y-axis-amplitude)

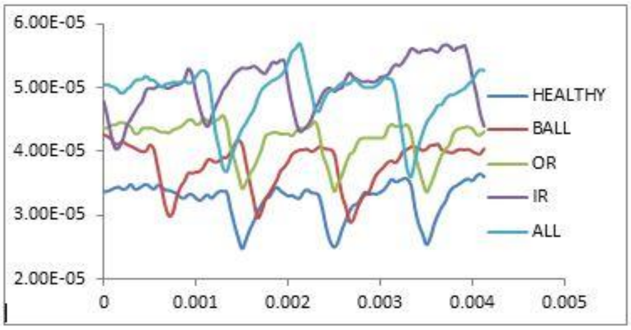

Figure 3. Frequency Response at a Speed of 500 RPM.

The graph shows the displacement due to vibration of the bearings at 500rpm speed. At 500rpm the healthy bearing has the lowest amplitude of vibrations. Faults on the inner raceway produce more vibrations that same sized faults on other raceways and ball. If the no. of faults in a single bearing increases the amplitude also increases but the amplitude of vibrations of bearing with multiple faults is not equal to the algebraic sum of the amplitudes of bearing with corresponding single faults.

Fig. 4 shows the frequency response at left bearing at a speed of 1000 rpm with ball fault, inner race fault, outer race fault, all faults and no fault bearings. This represents the vibrational characteristics of bearings at 1000rpm. The overall range of produced amplitude increased from 500rpm to 1000rpm.

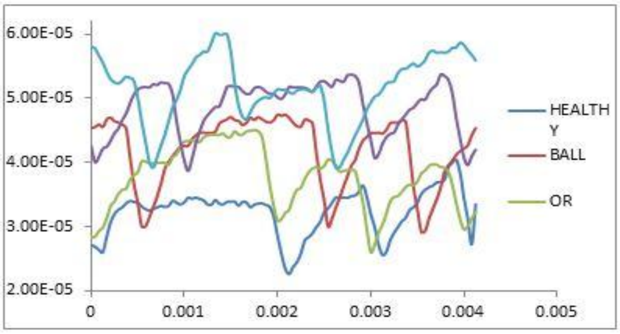

Figure 4. Frequency response at 1000 rpm

But the order of amplitudes remains same as the bearing of 500 rpm, that is ALL produced highest vibrational frequency followed by IR ,OR, BALL. The healthy bearing produces the most efficient vibrational frequencies

Fig. 5 shows the vibrational frequencies of the bearing at 1500rpm. In this case also the overall amplitude range is increased compared to the bearing at 1000rpm.

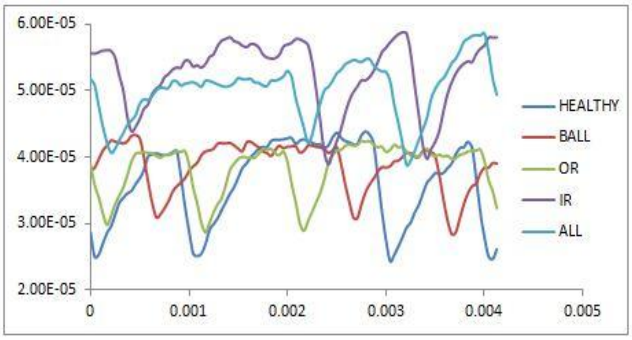

Figure 5. Frequency response at 1500 rpm

In this case the bearing with IR fault and ALL show significant equality of amplitudes, followed by BALL and OR.

Fig. 6 shows a bearing at 2000rpm. The overall amplitude range decreases when the speed increases from 1500 to 2000rpm. The order of amplitudes for different fault bearings at 2000 rpm differ by small values as the initial vibrations produced due to rotational speed of the bearing is so high that the vibrations produced because of small installation faults become less compared to the initial vibrations.

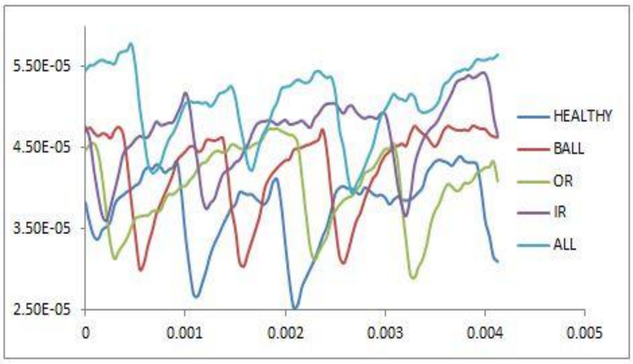

Figure 6. Frequency Response at 2000 rpm

Fig. 7 shows the bearing at 2500 rpm. The overall amplitude range is almost same when the speed of the bearing is increased from 2000 to 2500 rpm. The order of amplitudes for the bearing with different faults is ALL followed by BALL, IR and OR. The most efficient vibrations are produced by healthy bearing.

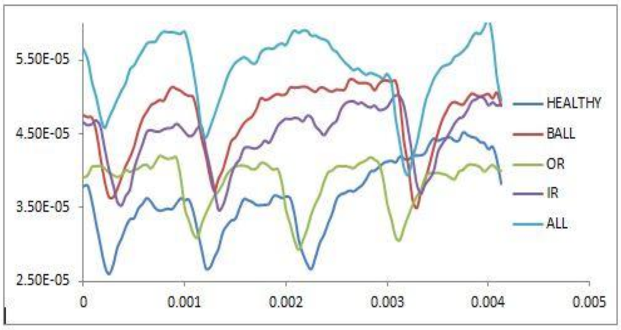

Figure 7. Frequency response at 2500 rpm

Fig. 8 shows the frequency response at left bearing at 3000 rpm.

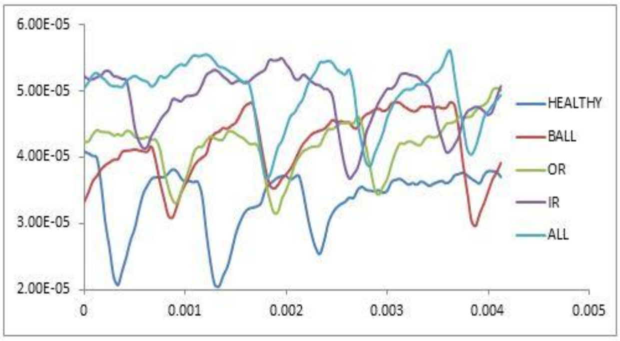

Figure 8. Frequency response at 3000 rpm

IV. CONCLUSION

The condition of the bearing affects the health of any rotating machinery. Even the newly installed bearing may have many faults. To study influence of the minute faults of the bearing components like balls, inner race and outer races several experiments were conducted. The overall amplitude increases when the speed increases from 2500 to 3000 rpm. The order of the amplitudes for bearings with all faults in the bearing is having highest frequency value and the amplitude of ALL faults and Inner Race faults are almost equal, followed by ball and outer race. The most efficient conditions are obtained by the healthy bearing.

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