Effect of Bearings on Vibration in Rotating Machinery

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Abstract: In rotary machines vibration is an inherent phenomenon which has the tendency to affect required performance. Amongst the different parameters that affect vibration, selection of appropriate bearing is the most critical component. In this work the effect of different types of bearing on vibration in rotary machines is studied and the magnitude of vibration produced by use of different set of bearings under the same condition of loads and rotational speeds were investigated. Bearings considered in this work were ball bearing, tapered roller bearing, thrust bearing and shaft material considered is of mild steel. From experimental result, it was noted that tapered roller bearing gives the highest amplitude of vibration among all the three bearings whereas the ball bearing gives least amplitude under similar operating conditions.

Keywords: bearing, rotary machines, vibration, shaft, stainless steel.

1. INTRODUCTION

In the manufacturing industry, rotary machines are widely used and bearing type plays a major role in such rotary machines [1]. A bearing is a machine element that constrains the relative motion to a desired motion, and reduces friction between moving parts [2]. Bearings supports rotary components like shafts within mechanical systems, and transfer axial and radial loads from the source to the structure supporting it [3]. There are various types of bearings, but selection of proper bearing plays an important role in the performance of rotary machines [4]. Because effective and consistent operation of these machines also depends on the type of bearings selected and their performance under vibration as well as all other related parts like shaft, housing, nuts, spacers etc. [5,6]. In this study, vibration produced by the use of different types bearing in rotary machines was examined and three bearings namely ball bearing, taper roller bearing and thrust bearing was selected.

2. SELECTION OF BEARINGS

In this work three different bearings were considered to study its influence on vibration in working conditions. A ball bearing uses balls that acts as a separation between
the bearing races. The use of a ball bearing is to decrease rotational friction and to sustain both radial and axial loads [7]. Tapered roller bearings consist of inner and outer tapered ring raceways along with tapered rollers. Their main purpose is to accommodate combined loads, i.e. both radial and axial loads simultaneously. The capacity of carrying axial load can be increased with increasing contact angle [8]. Thrust ball bearings, consist of ball bearings supported by a ring, that can be used in low thrust applications where there is little axial load. Their sole purpose is to take only axial loads but not radial loads. Thrust ball bearing can be separable as shown in Figure 1, i.e. shaft and housing washer, ball and cage assembly. The specification of bearings used in this work is shown in Table 1.

![Types of Bearing](image1.png)

**Fig. 1 Types of Bearing**

| Parameters            | Ball bearing | Taper roller bearing | Thrust bearing |
|-----------------------|--------------|----------------------|---------------|
| Part number           | 6002 RS      | 30202                | 51202         |
| Bore diameter (mm)    | 15           | 15                   | 15            |
| Outside diameter (mm) | 32           | 35                   | 32            |

### 3. EXPERIMENTAL SETUP

The test rig for experimentation is as shown in Figure 2. The setup consists of DC motor, support plates, counter weight, shaft, bearings and coupling. The rig consists of a shaft with a length of 780 mm and a diameter of 15 mm. A flexible coupling is used to couple shaft and motor to minimize effects of the high frequency vibration generated by the 0.5 HP motor. A phase induction motor PMDC (Permanent Magnet DC) motor 230Vis connected to the variable speed control unit for achieving variable speeds. The motor can run in the speed range of 0-3000 RPM. Two bearings fit into the mounting housing. A static load is applied by one aluminum disc with 100 mm diameter and a mass of 0.583 kg at the center of shaft made of stainless steel. An accelerometer is attached to the top of the bearing housing to measure the magnitude of vibrations. After this shaft is allowed to rotate slowly up to the desired speed by speed control unit. After the speed of shaft reaches to the desired speed it has been allowed to rotate at the same speed for some time to stabilize the amplitude of vibration. Once its stabilized reading will be noted down. The procedure continued followed for different speed ranges as well as...
bearings. The magnitude of vibration was measured by using a piezoelectric-type vibrometer where the pickup of the vibrometer was mounted on the test bed near to bearing.

4. RESULTS AND DISCUSSION

In this study three different bearings are examined (ball bearing, Taper roller bearing and thrust Bearing) and their amplitude values have collected. When speed increases gradually displacement (amplitude of vibration) also increases but its variation depends upon the kind of bearings used.

Table 2. Experimental data

| Speed (rpm) | Ball bearing | Taper roller bearing | Thrust bearing |
|-------------|--------------|---------------------|---------------|
| 500         | 0.001        | 0.006               | 0.0035        |
| 1000        | 0.002        | 0.0165              | 0.0105        |
| 1500        | 0.004        | 0.0365              | 0.0195        |
| 2000        | 0.005        | 0.0505              | 0.0395        |
| 2500        | 0.006        | 0.0935              | 0.0435        |
| 3000        | 0.007        | 0.0995              | 0.0475        |
As presented in Table 2, amplitude of vibration for Ball bearing varies from 0.001 to 0.007 mm. But for other two bearings this range is increasing. Aimed at tapered roller bearing displacement range is from 0.006 to 0.0995 mm. This increased displacement is because of its fitting construction (taper arrangement). For thrust bearing this range is from 0.0035 to 0.0475 mm which is less than tapered roller bearing. The experimental result obtained is shown graphically in Figure 3.

5. CONCLUSION

The outcome of bearings on vibration in rotary equipment was presented in this work to identify the magnitude of vibration caused by the use of different type of bearings. From this experiment, it was concluded that as speed increases in any rotary machines tapered roller bearing gives largest displacement because of its unique construction, whereas ball bearing gives lowest displacement as a result of point contact and Thrust bearing showed medium range of displacement level. So, it is preferable to use ball bearing over thrust bearing and tapered roller bearing to reduce the magnitude of vibration and to achieve better performance.

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REFERENCES

[1] S. Khanan, N. Tandon, and J.K. Dutt, “Fault size estimation in the outer race of ball bearing using discrete wavelet transform of the vibration signal,” Procedia Technology 12-19, 14 2014.

[2] V.N. Patel, N. Tandon, R.K. Pandy, “Vibration generated by rolling element bearing having multiple local defects on races,” Procedia Technology 312-319, 14 2014.

[3] Dipan S. Shah. Vinod N. Patel. “A review of dynamic modeling and fault identifications methods for rolling element bearings” Procedia Technology 447-456, 14

[4] A. Tandon, “ Vibration response of rolling element bearings in a rotor bearing system to a local defect under radial load,” ASME Transactions on Tribology, 128:252-261,2006.2014.

[5] AbhayUtpat, “Vibration signature analysis of defective deep groove ball bearings by numerical and experimental approach,” Scientific & Engineering Research, Volume 4, Issue 6, June 2013

[6] Patil M S, Mathew J, Rajendrakumar P K, Desai S, “ A theoretical model to predict the effect of localized defect on vibrations associated with ball bearing,” International Journal of Mechanical Sciences; 52: 1193–1201,2010.

[7] A Choudhury, N Tandon, “A theoretical model to predict the vibration response of rolling bearings to distributed defects under radial load,” Jr. of Vibrations & Acoustics ,120, 214-220, 1998.

[8] DumitruN.Olaru , Mihaela RodicaD.Balan , Ana Tufescu, Vlad Carlescu , Gheorghe prisacaru, “ Influence of the cage on the friction torque in low loaded thrust ball bearings operating in lubricated conditions,” Tribology international ,2016.

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