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Experimental Investigation of the Journal Bearing Performance with Helical Groove on Shaft surface of Journal Bearing

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Abstract: Rotating machines plays a vital role in modern industries from small scale to huge power plants. The soul of the rotating machine is shaft and entire load of the shaft is taken by the bearings. Bearing health plays a significant role in the performance of rotating machines either machine consumes power or generates power. This article presents the experimental investigation of journal bearing performance with a helical groove cut on the journal. The results of the investigation on a bearing with a helical groove on the journal (load capacity, oil temperature, and oil flow rate) were compared with those obtained for a standard bearing with a plain journal. The previous computer simulation results, indicated that a groove of appropriate dimensions on the journal intensifies axial oil flow and does not impair load capacity. The complete experiment was performed on the bearing apparatus. The results shows that the shaft have grooves on its surface delivers better performance than that of standard plane shaft. The shaft having grooves controls the temperature rising at various speed of the shaft and generate less torque in comparison to the shaft that have no grooves. This investigation shows that the dimension of the groove plays a vital role in improving the bearing life and its performance because an appropriate size groove can control the temperature rising at higher speed without effecting the load bearing capacity of the bearing.

Keywords: Journal bearing, Helical groove, Frictional torque

I. INTRODUCTION

Primary function of bearing to support load and reduce friction to minimize loss of power in friction. Journal bearing are of two types from the lubrication point of view; one is hydrostatic and other one is hydrodynamic. Performance of the journal bearing is dependent on various design and operating parameters. Journal bearing gives its best when operated under the designed load, speed, ambient temperature, with designated lubricant etc. [1-3].
The author studied particle induced friction model in the jornal beairng experimentally and verified the model with good agreement [4]. The importance of friction and wear control cannot be overemphasized for economic reasons and long-term reliability. Authors have presented the reviews of different works in the area of wear and friction in hydrodynamic journal bearings and tries to find out latest developments and trends available in industries and other fields in order to minimize the total equipment cost, minimize damages and maximize the safety of machines, structures and materials [5]. M. A. Ahmad *et. al.* have experimentally studied the effect of oil groove location on temperature and pressure distribution in hydrodynamic journal bearing, change in oil groove location affects the pressure and temperature distribution to some extent [6]. F. M. Meng *et. al.* showed from their work that the load carrying capacity is increased and friction coefficient is reduced in a compound dimple in journal bearing as compared to simple dimple [7]. D. Zenebe Segu *et. al.* worked on improvement in tribological properties of surface by the introduction of multi texture on the surface, which resulted in reduced friction under dry and wet condition [8]. F. Brito *et. al.* presented in their work the effects of single and twin grooves axial groove on journal bearing were studied under varying loading conditions to improve lubrication [9]. M. Fesanghary *et. al.* in presented experimentally and theoretically shape optimization of groove shape for enhancement of load carrying capacity of journal bearing [10].
From the study of literature, it is seen that load carrying capacity of journal bearing can be increases and friction coefficient decreases for the textured surface or bearing with groove. In many literatures groove is considered on journal bearing and a lot of work has been done on shape, size and number of groove optimization. The proposed work considers groove on the journal surface in place of groove on the hydrodynamic journal bearing to study the effect on bearing performance.

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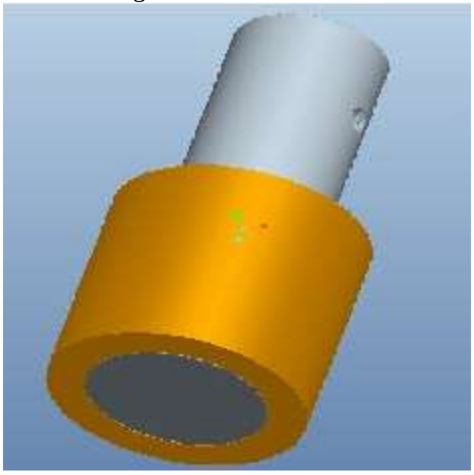
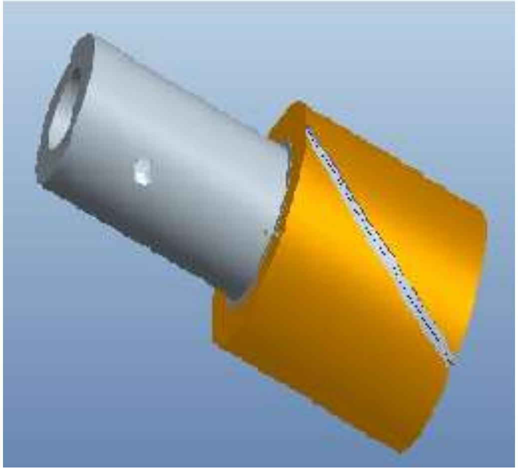
II. METHODOLOGY

3-D model of shaft was prepared for shafts with direct measurement of existing shaft for plain shaft and a grooved shaft which is show Figure 1.



Without groove



With groove

Figure 1 Shaft 3D models

The shaft is consisting of two parts as shown first one is mild steel stepped shaft with 35 mm diameter upto 50 mm and 30 mm for the 60 mm length. A brass sleeve of 35.01 inner diameter and 50 mm length was press fitted over the 50 mm length of mild steel shaft. The other side of the shaft which has 30 mm outer diameter, a hole of 20 mm was drilled into it to mount it on the motor shaft. Both the shafts as shown in Figure 2, were fabricated for the experimental work in the central work shop facility in the institute. Two helical groove was cut on the brass sleeve with width 2.8 mm, depth 0.6 mm, helix angle 27º with the shaft axis.

Shaft without groove

Shaft with groove

Figure 2 Shaft after Fabrication

Both plain and grooved shafts are used one by one on bearing apparatus under different radial loading condition at different speeds. The experiment was performed at speeds of 900, 1200 and 1500 RPM with loads of 6 kg, 7 kg, 8kg and 9 kg. Friction torque was determined under different loading condition for both the shafts. Friction torque is calculated by measuring the load required at the moment balance arm at a particular distance from bearing centre to keep moment balance arm in equilibrium position, since it is tilted when friction torque rotates the bearing housing in the direction of shaft rotation which disturbs its equilibrium position. The product of load applied for balancing the arm and the distance at which it is applied gives friction torque. The force is applied at a distance of 200 mm from the shaft centre in every case.

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III. EXPERIMENTAL SETUP

Bearing Apparatus and other instruments

The bearing apparatus as shown in Figure 3, it has a DC electric motor single phase 230 V, 50 Hz, 1500 RPM. Shaft which is to be studied fitted directly on the motor shaft, and a bearing is fitted over the shaft. The bearing housing has an arrangement for hanging load, it is fitted with a pressure gauge for oil pressure and an attachment for thermometer for oil temperature. The bearing housing also has a moment control arm connected with it, which is used for applying load to keep it in horizontal condition. It has a lubricant reservoir which is connected to bearing through a flexible tube to make supply of lubricant to the bearing.

Figure 3 Bearing Apparatus

A mechanical type tachometer as shown in Figure 4 was used for measuring speed of the shaft. Tilt of the moment balance arm is detected with the help of protector located between bearing and motor which is not visible in the Figure 3.

Figure 4

IV. OBSERVATIONS AND RESULTS

The observations are recorded from the experiment and friction torque calculated using equation shown below;

$$\text{Friction Torque} = \text{Balancing Force} \times \text{Distance}$$

The calculated torque for shaft without groove is given in the

Table *1* under different speed and loading condition. Friction torque is increasing the load but it decreasing with increase in speed. At low running speed the friction is high because of hydrodynamic pressure is not sufficient to take the load. There is 30% reduction of torque when the speed goes to 1500 RPM from 900 RPM when the load is 6 kg, and a 63% reduction in torque is seen when speed jumps 900 RPM from 1500 RPM at a load of 9 kg.

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Table 1 Friction torque in Nm for shaft without groove

Load \ Speed	1500 RPM	1200 RPM	900 RPM
6 kg	0.7	0.9	1.0
7 kg	1.0	1.2	1.4
8 kg	1.1	1.4	1.6
9 kg	1.8	2.1	2.2

Friction torque calculated for grooved shaft under different loading condition and speed as mentioned in the Table 2. It can be observed that the torque increases with the increase in load and decrease in speed of the shaft. There is 46% torque reduction when the shaft runs at maximum speed as compared to minimum speed with minimum load of 6 kg. A 25 % torque reduction at maximum speed as compared to minimum speed with maximum load of 9 kg.

Table 2 Friction torque in Nm for shaft with groove

Load \ Speed	1500 RPM	1200 RPM	900 RPM
6 kg	0.5	0.7	0.96
7 kg	0.5	0.7	1.1
8 kg	0.6	1	1.3
9 kg	1.5	1.7	2

Frictional torque with grooved and without shaft is shown in Figure 4. It can be observed that friction torque is less for grooved shaft as compared to shaft without groove for 1500 RPM to 900 RPM. It can also be seen that the load is increasing from 6 kg to 9 kg friction torque is also increasing.

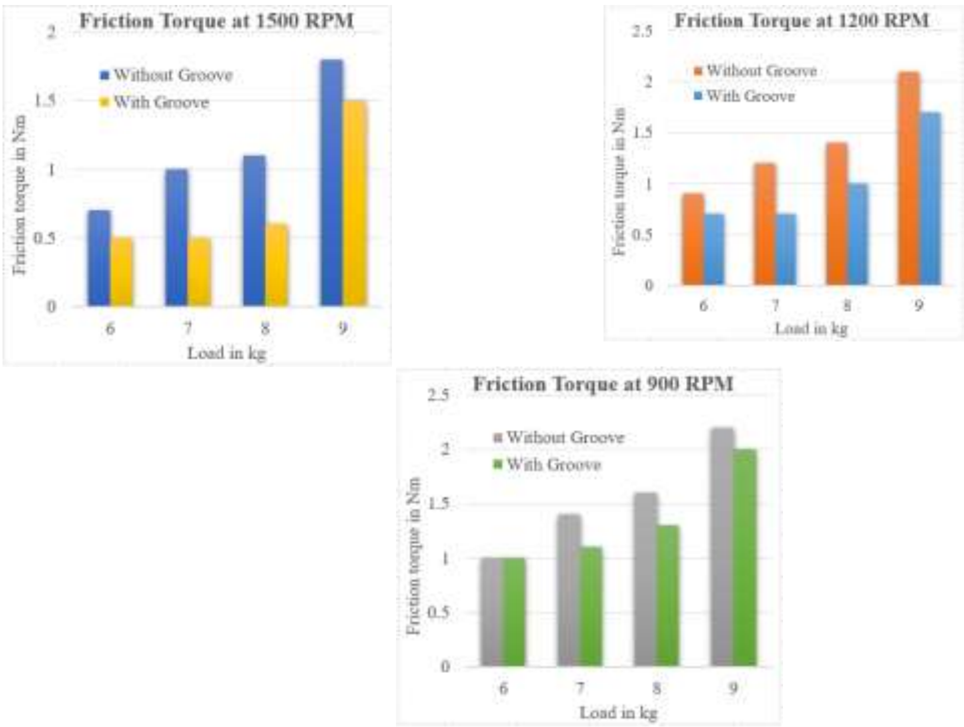

Figure 4 Friction torque reduction with grooved shaft as compared to without grooved shaft at Different speeds

V. CONCLUSION

Reduction in frictional torque is achieved with a significant magnitude with grooved shaft. Frictional torque reduction is achieved in with grooved shaft, this will reduce the frictional power loss and hence power consumption will be reduced. In larger machines where load is very high, grooved shaft would help in significant reduction of power consumption of the machine. Fabrication of the grooved shaft would increase the manufacturing cost of the shaft but in long terms the cost may be recovered. However, the size of the groove was not optimized, better results can be expected with the proper sizing and number of grooves. Groove was cut on a milling cutter which was not very precise, but it gave a good result in friction torque reduction.

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