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Enhancing the working of Journal Bearing using Internal cavity

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Abstract— Hydrodynamic journal bearings are commonly used in various rotating machines such as pumps, compressors, fans, turbines and generators are widely used in industries. A journal bearing is the most common hydrodynamic bearing in which, a circular shaft, called the journal, is made to rotate in a fixed sleeve is called the bearing. Their design and construction may be relatively simple, but the theory and operation of these bearings can be complex. Surface texturing helps in effective lubrication and thus it optimizes the bearing performance. To improve the performance of bearings the use of textured surfaces having different shapes of textures and at different locations of the texture zone can be an effective approach.

During my work the parameters like speed of the shaft, bearing context texture and different loading conditions are of prime importance and are considered to judge the performance of the journal bearing. By varying the bearing surface texture, force applied and speed of the shaft, pressure profile is generated for each combination of force, speed and bearing texture and the bearing performance is observed. After obtaining the effects of the parameters on the performance of the journal bearing, the optimum combination can be found for each bearing texture.

Keywords— Journal bearings ; Surface texturing ; Pressure profile ; Bearing texture

INTRODUCTION

A Bearing is a machine element which supports or guides a moving element permitting its relative motion with minimum friction. The term "bearing" is derived from the verb "to bear"[1] a bearing being a machine element that allows one part to bear (to support) another. Bearings are used to prevent friction between parts during relative movement. One of the basic purposes of a bearing is to provide a frictionless environment to support and guide a rotating shaft. The types of machinery we are concerned with range from small to high speed spindles to motors, blowers, compressors, fans, and pumps to large turbines.

JOURNAL BEARING

A journal bearing is the most common hydrodynamic bearing in which, a circular shaft, called the journal, is made to rotate in a fixed sleeve is called the bearing. The bearing and the journal operates with a small radial clearance of the order of 1/1000th of the journal radius. Properly installed and maintained, journal bearings have essentially infinite life.

A journal bearing, simply stated, is a cylinder which surrounds the shaft and is filled with some form of fluid lubricant. In this bearing a fluid is the medium that supports the shaft preventing metal to metal contact. The most common fluid used is oil, with special applications using water or a gas.

In machinery they fall into two primary categories: anti-friction or rolling element bearings and hydrodynamic journal bearings. The primary function of a bearing is to carry load between a rotor and the case with as little wear as possible. Industrial machinery with high horsepower and high loads, such as steam turbines, centrifugal compressors, pumps and motors, utilize journal bearings as rotor supports. The use of journal bearings is specialized for rotating machinery both low and high speed. This since they have significant damping fluid film journal bearings have a strong impact on the vibration characteristics of machinery.

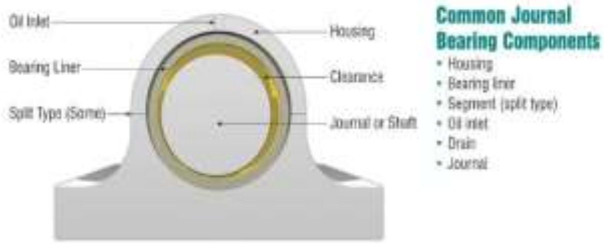


Fig.1 Journal Bearing

Journal or plain bearings consist of a shaft or journal which rotates freely in a supporting metal sleeve or shell. There are no rolling elements in these bearings. Their design and construction may be relatively simple, but the theory and operation of these bearings can be complex. An additional characteristic of journal bearings is damping. This type of bearing provides much more damping than a rolling element bearing because of the lubricant present. More viscous and thicker lubricant films provide higher damping properties. As the available damping increases, the bearing stability also increases. A stable bearing design holds the rotor at a fixed attitude angle during transient periods such as machine startups/shutdowns or load changes. The damping properties of the lubricant also provides an excellent medium for limiting vibration transmission. Thus, a vibration measurement taken at the bearing outer shell will not represent the actual vibration experienced by the rotor within its bearing clearances.

In a journal bearing at the rest condition there is a metal to metal contact between the journal and the bearing and when the shaft starts rotating the journal gets lifted and after achieving the speed there is a thin fluid film between the journal and the bearing which avoids the metal to metal contact. The phenomenon is shown in Figure.2

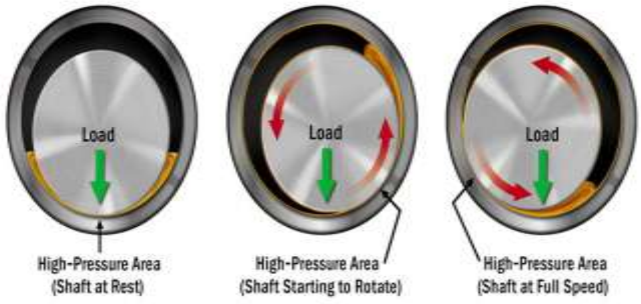


Fig.2 Journal Bearing At Running Condition

In plain journal bearing load is supported by a high pressure oil region as shown in figure 1.4. Each line in the pressure profile represents an oil pressure vector at the centerline of the bearing. The sum of the vertical components add up to the applied load and the horizontal components cancel out for equilibrium. Oil inlet ports are placed in areas of minimum pressure [2]

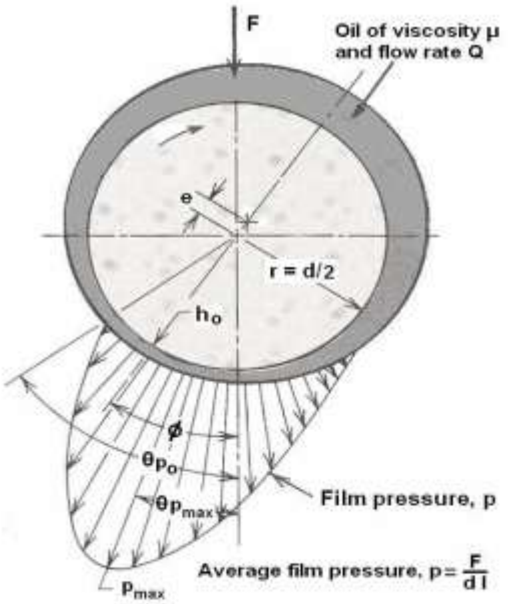


Fig. 3 Pressure Profile

SURFACE TEXTURING

The texture of any surface is defined by the inherent surface topography it exhibits. All surfaces have a unique texture and structure and all manufactured surfaces are 'engineered' [3]. Design engineers have an understanding of the relationship between surface texture and its function. Deterministic surface textures are those that have a specific structured pattern and that are amenable to a sensible description. Such deterministic surface textures are deliberately manufactured in order to improve the functionality of any surface.

In the field of Tribology, engineered surfaces are found to be beneficial in many contact applications with or without the presence of any lubricant. Applications of engineered surfaces are found in mechanical face seals, thrust bearing pads and journal bearings to name a few. In the above mechanical components, reduction in friction and the generation of load support is of paramount interest for most applications.

In these cases, the deterministic surface textures/features are patterned surface features having arbitrarily specified geometries, low aspect ratios and having dimensions of the order of 10-5 to 10-6 m. These surface features are also known as micro asperities. On fluid bearings and seals, control of lubrication properties using micro asperities can alter load capacity, friction torque, dynamic stiffness and damping coefficients among others.

Changing the density and diameter of dimples on the load bearing surfaces had a significant effect in reduction of friction. They then determined the dimple diameter and distribution density which resulted in the minimization of friction. It was also shown that certain sliding velocities would produce a negative effect due to mechanisms such as side leakage. Surface texturing can also affect the regime of lubrication [4].

JOURNAL BEARING SETUP DETAILED VIEW

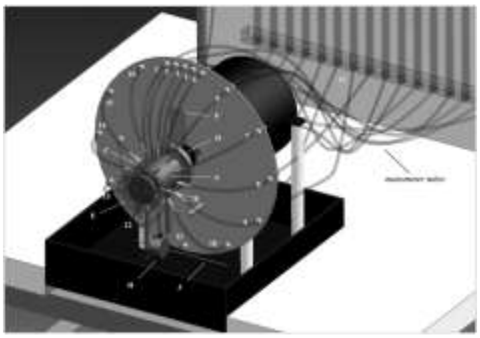


Fig. 4 Journal bearing setup detailed view

Where, A = Journal or shaft

B = Motor shaft

C = Bearing

D = Bearing cover

E = Screws attached to the bearing cover

G = Plate to hold the manometer tubes

H = Loading arrangement

SPECIFICATIONS OF THE LABORATORY SETUP

Diameter of journal = 81.50 mm

Diameter of bearing = 82.125 mm

Bearing length = 69.40 mm

Weight of balancing load = 2 kg

Motor = D.C. 0.5 HP, 1500 rpm variable speed

Supply required = A.C. 1 ph. 230v.

Motor control =4Amp,D.C. dimmer for motor speed control

Manometer board with 16 tubes of 300cm,

height with suitable scales and adjustable oil supply tank.

Recommended oil = SAE 40

PROCEDURE OF THE EXPERIMENT

1. Fill the oil tank by using oil lubricating oil under test and position the tank at the desired height.
2. Drain out the air from all the tubes on the manometer and check level balance with supply level.
3. Check that some oil leakage is there. Some leakage of oil is necessary for cooling purpose.
4. Check the direction of rotation and increase the speed of motor slowly.
5. Set the speed and let the journal run for about half an hour until the oil in the bearing is warmed up and check the steady oil levels at various tapings.
6. Add the required loads and keep the balancing rod in horizontal position by moving balancing weight on the rod and observe the steady levels.
7. When the manometer levels have settled down, take the pressure readings on 1.12 manometer tubes. For circumferential pressure distribution and tubes for axial pressure distribution.
8. Repeat the experiment for various speeds and loads.
9. After the test is over set dimmer to zero position and switch off main supply.
10. Keep the oil tank at lower most position so that there will be no leakage in the idle period.

BEARING TEXTURING

To determine the load carrying capacity of the journal bearing, there is the provision for varying the load at the bottom of the bearing cover. By changing the load and measuring the difference in pressure one could examine the effect of the load and determine the load carrying capacity. Bearings of different textures have been produced to carry out experiments and to examine the effect of the bearing texture on the performance of the bearing by measuring the pressure profile generated. Keeping the shaft as a reference and designing a bearing to it considering all the constraints. Length/Diameter ratio = 0.85

$\frac{r}{c}$= 600–1000

BEARING WITHOUT TEXTURE

The detailed view of the bearing Without Texture is shown in Figure.5

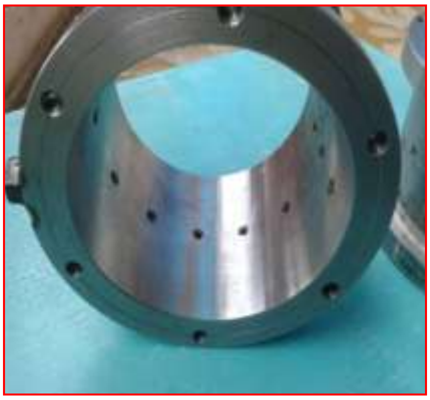


Fig. 5 Bearign without texturing

Diameter of Bearing = 82.125 mm
Diameter of Shaft = 81.50 mm
Length of the bearing = 69.40 mm
Oil supply head = 155 mm
Temperature = 320 C
Oil used = SAE 40
Surface roughness of the bearing = Ra avg. = 0.62 µm

BEARING WITH TEXTURE-1

The detailed view of the bearing Texture-1 is shown in Figure.6

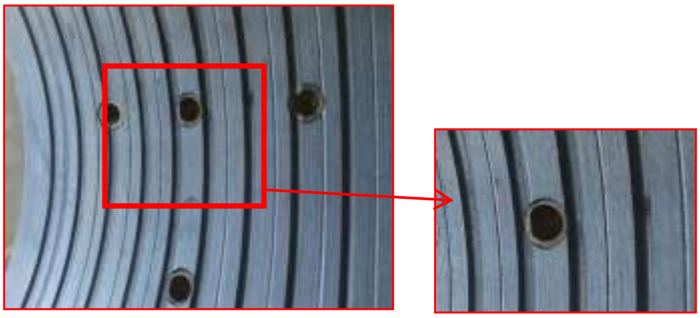


Fig. 6 Bearign with texture-1

Diameter of Bearing = 82.125 mm
Diameter of Shaft = 81.50 mm
Length of the bearing = 69.40 mm
Oil supply head = 1550 mm
Temperature = 32^0C
Oil used = SAE 40

OBSERVATION TABLE

(1) Bearing without Texture, at 1000 rpm

Tube No.	Head Pressure (Po)	Reading Pressure (P)	P-Po
1	165	86.5	-78.5
2	165	95	-70
3	165	105	-60
4	165	115	-50
5	165	128.5	-36.5
6	165	155	-10
7	165	180	15
8	165	105	-60
9	165	84	-81
10	165	84.5	-80.5
11	165	85	-80
12	165	86	-79

Table:-1 Bearing without Texture, at 1000 rpm

(2) Bearing Without Texture, at 2000 rpm

Tube No.	Head Pressure (Po)	Reading Pressure (P)	P-Po
1	165	110	-55
2	165	127	-38
3	165	130.5	-34.5
4	165	134	-31
5	165	145.5	-19.5
6	165	165	0
7	165	201.5	36.5
8	165	165.5	0.5
9	165	47.8	-117.2
10	165	91	-74
11	165	103.6	-61.4
12	165	106	-59

Table:-2 Bearing without Texture, at 2000 rpm

(3) Bearing with Texture-1, at 1000 rpm

Tube No.	Head Pressure (Po)	Reading Pressure (P)	P-Po
1	165	178	13
2	165	185	20
3	165	191	26
4	165	198	33
5	165	206	41
6	165	210	45
7	165	230	65
8	165	156	-9
9	165	115	-50
10	165	148	-17
11	165	153	-12
12	165	163	-2

Table:-3 Bearing with Texture-1, at 1000 rpm

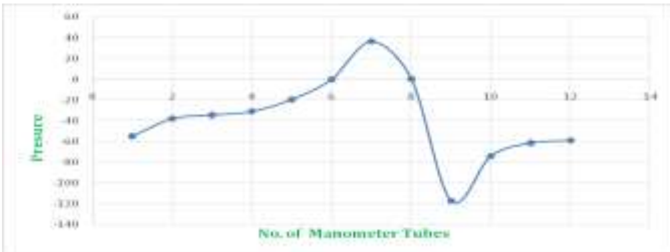
(4) Bearing with Texture-1, at 2000 rpm

Tube No.	Head Pressure (Po)	Reading Pressure (P)	P-Po
1	165	161	-4
2	165	168	3
3	165	174	9
4	165	183	18
5	165	190	25
6	165	198	33
7	165	220	55
8	165	90	-75
9	165	121	-44
10	165	143	-22
11	165	150	-15
12	165	146	-19

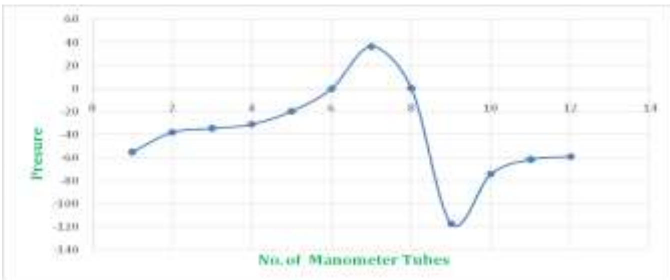
Table:-4 Bearing with Texture-1, at 1000 rpm

GRAPHS

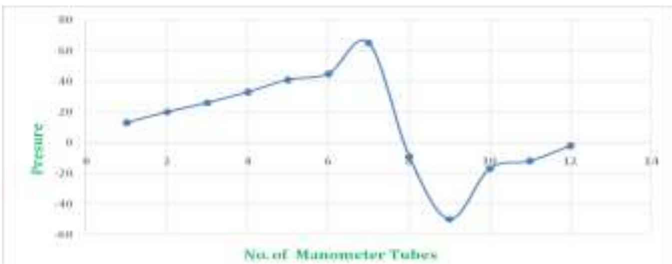
(a) Graphs Bearing without Texture, at 1000 rpm



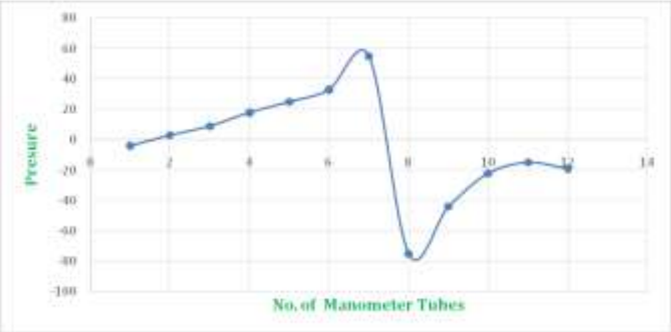
(b) Graphs Bearing without Texture, at 2000 rpm



(c) Graphs Bearing without Texture-1, at 1000 rpm



(d) Graphs Bearing without Texture-1, at 2000 rpm



CONCLUSION

On the Basic of Experiment Data from Table 1 to 4 , We conclude that the Texure-1 bearing gives more pressure and so we have find optimum result in both the case, 1000 rpm and 2000 rpm. we can also improve the performance Journal bearing with the same.

By determining the oil film pressure in hydrodynamic journal bearings, it is possible to increase knowledge about the true operating conditions of bearings. The knowledge can be used in the development of safer and more efficient machines and engines with hydrodynamic journal bearings that carry high and dynamic load.

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