

# Experimental Investigation of twin Groove Hydrodynamic Journal bearing with different Hydraulic Oils (15W40, 20W40, Refined Oil)

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## Abstract

This paper presents an experimental study of pressure distribution on hydrodynamic journal bearing with twin groove (5mm) using SAE 15W40, 20W40 and refined oil. In this study the pressure behavior of different lubricant with twin groove hydrodynamic journal bearing has been investigated. Twin Groove Hydrodynamic Journal bearing test rig (TGHJBTR) is used to test the 70 mm diameter and 100 mm long bearing ( $l/d = 1$ ) made of Brass. Test bearing is loaded mechanically. The space between the shaft and the bearing is filled with oil. Pressure distribution circumferentially investigation has been carried out applying one unloading and three loading conditions, with operating at journal rotational speed of 1120 rpm. The pressure distributions are validated with the experimental results of Desai and Patel [1]. The agreement observed between present work and experimental published data is acceptable. The analysis shows that present data deviates 10 - 15% from available publication.

## 1. Introduction

A bearing is machine element support another moving element. It permits a relative motion between the contact surfaces of the member, while carrying the load. The concept behind a bearing is very simple i.e. when things slide, the friction between them causes a force that tends to slow them down. Bearings reduce friction by providing smooth inner and outer metal surface. These surfaces bear the load, allowing the device to spin smoothly. Due to technological advances in last few decades the operating conditions of machine are becoming tough, this has necessitated that the design of bearing should be based on more accurately predicted design data. As bearing are the most essential part of machines, which bear load so they are subjected to most hostile conditions of wear and fatigue. The lubricant is supplied to the bearing under atmospheric pressure through a hole or a groove in the low pressure zone. Lubricant supply to the bearing is one of the main aspects to meet these new requirements. A journal bearing fed by two axial grooves has good load carrying capacity friction. Among the previous works on two axial groove oil journal bearings; Brito et al. [1] made a study with a single and twin axial groove configuration when heavily loaded. It was found that twin groove configuration might actually deteriorate the bearing performance when compared with single groove arrangement, due to uneven lubricant through each groove. Naimi et al. [2] studied hydrodynamic short bearing with a circumferential central feeding groove. The presence of the groove increases the eccentricity ratio and decreases the attitude angle compared to a conventional bearing. Increase in eccentricity thus increases the oil film maximum pressure in each half bearing. Desai and Patel [3] studied journal bearing with central circumferential groove at the center of the bearing. The groove divides the pressure distribution curve into two lobes and reduced the minimum film thickness thus increasing oil film maximum

pressure. So the behavior of Hydrodynamic journal Bearing is dependent upon lubricant feed hole position. It is essential to study experimentally with the help of a test rig. An attempt has been made in the present work to fill this gap. Kumar and Gupta [4] studied experimentally pressure distribution on hydrodynamic journal bearing with 10W40 multi grade oil. Hydrodynamic journal bearing test rig (HJBTR) is used to test the 40 mm diameter and 40 mm long bearing ( $l/d=1$ ) made of Bronze. A constant load of 860 N is applied at various journal rotational speeds of 1000, 1500, 2000 rpm. Various parameters like frictional torque, oil temperature and pressure at 10 different sensors along circumferential direction were recorded from hydrodynamic journal bearing test rig (HJBTR). The experimental plot of pressure ratio v/s sommerfeld number indicates that the working conditions are in the stable hydrodynamic regime. L Costa et al. [5] investigate theoretically the influence of oil supply condition on the performance of a journal bearing. The supply conditions considered were oil supply temperature, supply pressure, groove length and groove location. The hydrodynamic pressure distribution inside the bearing has been determined using realistic supply conditions. Oil flow rate was affected by all supply parameters studied. Power loss, maximum bush temperature and minimum film thickness were mainly dependent on oil supply temperature. An axial groove located at  $90^0$  to the load line gave rise to more favorable bearing performance characteristics.

## 2. Theoretical Aspect

Fig.1 shows hydrodynamic bearing with twin groove diametrically opposite to each other. Due to hydrodynamic action, a huge amount of heat is generated which is carried away by lubricant flow. Normal lubricant flow is insufficient to carry it away; an additional quantity must be supplied. Two additional grooves in the bearing are thus used to ensure maximum flow of lubricant and to obtain the

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greatest cooling effect. The effect of the groove is to create two half bearings, each having a smaller  $l/d$  ratio than the original. The groove divides the pressure distribution curve into two lobes and reduced the minimum film thickness. The presence of the groove increases the eccentricity ratio and decreases the attitude angle compared to a conventional bearing. Increase in eccentricity thus increases the oil film maximum pressure in each half bearing. Two grooves in the middle of the bearing are useful for applications where the load changes directions. These grooves are mostly used in crankcase bearings and automotive turbocharger bearings.

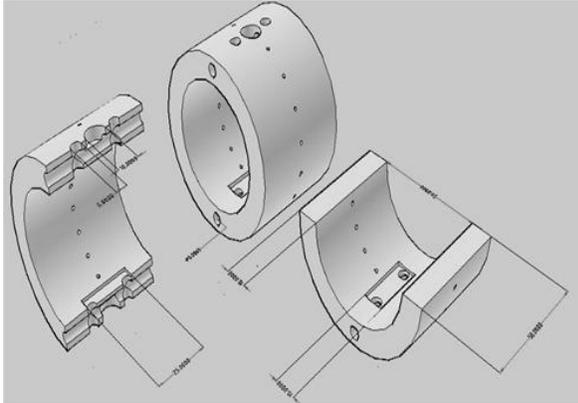


Fig. 1. Hydrodynamic Twin Groove Journal Bearing

### 3. Principal of HD Lubrication

Hydrodynamic lubrication (HL) is generally characterized by conformal surfaces. In this case, since the journal center is slightly displaced from the bearing center in a diagonally downward direction due to the bearing load, the clearance between the journal and the bearing metal varies in the circumferential direction. At rest journal is supported over the bearing surface confirming metal to metal contact. When journal starts rotating at low speed, at this condition either a metal to metal contact or an almost negligible oil film thickness will prevail. In the region where the clearance becomes smaller in the direction of journal rotation, the oil film forms a wedge and pressure is generated in it due to the journal rotation. This is called the wedge effect of an oil film. The bearing load is supported by the oil film pressure and the journal floats on the oil film. The existence of this positive pressure implies that a normal applied load may be supported. The Magnitude of the pressure developed (usually less than 5 MPa) is not generally large enough to cause significant elastic deformation of the surfaces. Therefore, the frictional

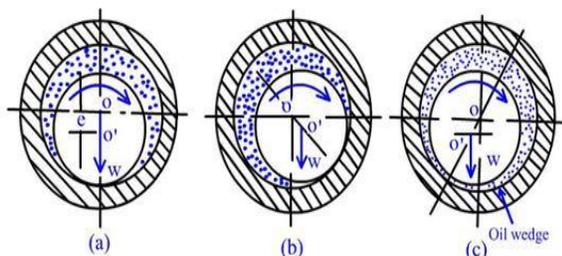


Fig. 2. Operation of Journal Bearing: (a) Rest (b) Low Speed (c) High Speed

resistance is very small. Journal bearings range in size from the very small, such as those supporting rotating grinders for dentistry, to the very large, such as those supporting steam turbines, generators, and hydraulic turbines, for example

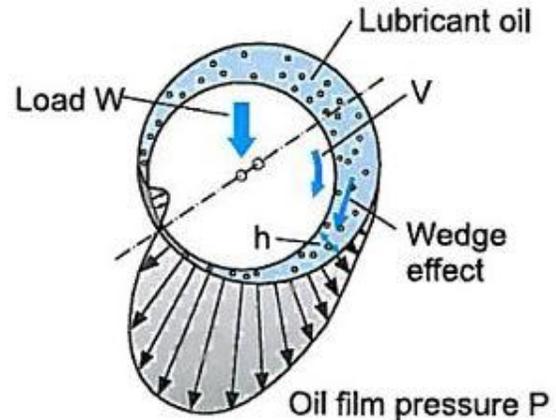


Fig. 3. Pressure Distributions

Positive pressure generates in the convergent region and either negative or zero pressure occurs in the cavitations zone of the bearing.

### 4. Experimental Setup

A journal bearing test rig, shown in figure 4, is used to test the 70 mm diameter and 100 mm long bearing ( $l/d = 1$ ) made of Brass. The journal is made of high carbon steel. Two grooves are provided diametrically opposite to each other for better oil supply. The bearing is loaded mechanically. The  $50\mu\text{m}$  radial clearance was provided in order to get turbulence with low viscous oils. The main feature of this bearing is the oil supply ports. The oil enters from a 10 mm hole and divides into two 5 mm holes which in turn merge with the groove. This is the oil feed arrangement to the bearing. Journal bearing has 8 pressure tapings and an equal amount of temperature tapings around its circumference. Pressure tapings are being attached to the pressure gauges with the help of PU pipes. Temperature tapings are being attached to thermocouples to measure temperature over the circumference of the journal bearing. Thermocouple end wires are connected to digital temperature gauge. There is an oil reservoir vertically placed and can be adjusted at required height. Lubricant supplied to bearing with rubber tubes attached to bearing. DC motor equipped with variac used to obtain the different journal speed and for providing variable voltage to motor. Pressure is measured with the help of pressure gauges. The commonsense idea that the two groove placed diametrically opposite to each other will improve the performance of the journal bearing was to be tested. Earlier Brito et. al. [1] had carried out an experimental analysis of such a system. In the present work there are the following changes:

- Instead of the temperature readings alone pressure readings are also taken at various points on the periphery of the bearing.
- The oil supply is through gravity and pressure feeding of oil is avoided to make it more practical for industrial application.

- The size of the bearing is taken much smaller than that investigated by Brito et. al [1].



Fig. 4. Experimental Test Rig

### 5. Experimental Parameters

The bearing performance characteristics were obtained for the following parameters:

Bearing geometrical properties:

Table: 1. Bearing Geometrical Properties and Operating Conditions

Bearing Geometric Parameters	Symbol	Units	Values
Bush ID(nominal)	D	mm	50
Bush OD	D	mm	70
Bush length	L	mm	100
Length/Diameter Ratio	L/d	mm	1
Journal radius	R <sub>j</sub>	mm	25
Diametric clearance	C <sub>d</sub>	mm	.050
Groove length	A	mm	5
Groove width	W	mm	2
Rotational speed	N	rpm	1120
Applied load	W	Kg	.25, .5, .75
Oil supply temp.	T <sub>amb.</sub>	0C	39

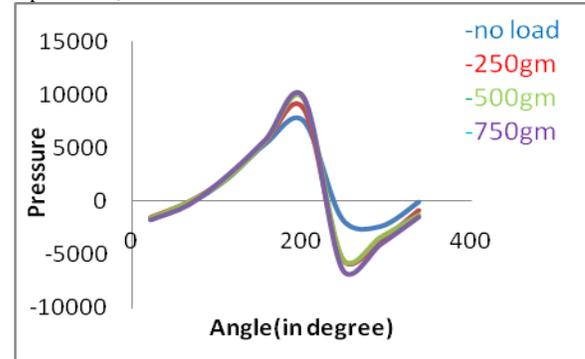
Lubricant Properties:

Properties	15W40	20W40	Refined Oil
Boiling point $c^0$	>316	>315	>290
Pour point $c^0$	-30	-18	-16
Flash point $c^0$	>215	>205	>260
Relative density(Kg/ $m^3$ )	874	882	920
Viscosity at 400C(mm/sec)	98	121	42
Viscosity at 1000C(mm/sec)	14	14	9

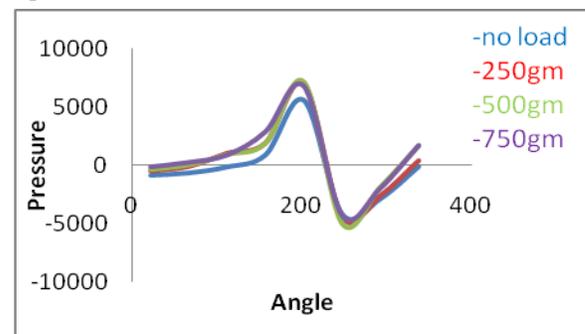
### 6. Results

Results of pressure distribution for hydrodynamic two grooves bearing for different lubricants at 1120 rpm are shown in the figure below. Pressure distribution increases with increase in load.

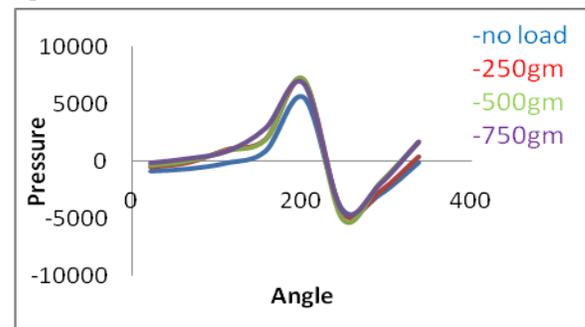
Rpm-1120, lubricant-15W40



Rpm-1120, lubricant-20W40



Rpm-1120, lubricant-Refined oil



From the graphs it is concluded that the pressure profile follow the same pattern as followed by the single groove bearing and as the load increases the pressure also increases. Maximum pressure obtained for 750gm load for lubricant 15w40.

### 7. Conclusion

Based on the results presented in previous chapter, the following conclusions have been drawn for different lubricants:

The maximum pressure observed during working of twin groove hydrodynamic journal bearing is 9768.302 N/m<sup>2</sup> at 0.75kg and 1120 rpm for lubricant SAE 15W40.

- Pressure increases with increase in load and follows sinusoidal form at the periphery of bearing.
- The pressure curve follows the same pattern as followed in case of single groove bearing.

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