VIBRATION STUDY ON JOURNAL BEARING

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ABSTRACT

In machines, notably in engines and power plants, hydrodynamic bearings are frequently utilised. A revolving journal or sleeve is what makes up a bearing. The load is supported by the pressure that builds up in the convergent wedge with a changing form that is filled with a lubricant film. The primary goal in designing journal bearings is the load-carrying capability at the desired speed. To prevent contact between mating surfaces, the lubricant film's thickness must also be adequate. The lubricant film produced by the journal rotation in this case serves to isolate the bearing surface from the journal surface. The suitable lubricant must be chosen based on the application field as lubricants lose their film as a result of changes in temperature and pressure distribution. To determine the pressure distribution over the journal bearing for varied loads and speeds, we selected specific lubricants. We have decided to investigate the vibration pattern for two lubricants, namely spin 22 and 20W40, collected by accelerometer and analysed by vibration analyzer to track the performance of journal bearing with various lubricants. With the help of the pressure distribution for each condition and the vibration patterns for various load and speed conditions for both oils provided in this project report, it is possible to determine the journal bearing's performance under each situation and choose the optimum lubricant to use.

Keywords: *Journal bearing, Lubricant, spin 22, 20W-40, Pressure profile, Vibration Spectrum*

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1. INTRODUCTION

As journal bearings are the most frequently utilised component in high-speed rotary machines, it is crucial that they function properly and receive high-quality lubrication to ensure normal rotational operation. These factors highlight the importance of ongoing investigation and study of anomalies in journal bearing performance. When the rotating speed of the shaft exceeds the critical speed of the rotor system, oil whirl and oil whip—common journal bearing failures—are brought on by the instability of the oil film. Machine components called journal bearings allow working parts to move in relation to one another while also loading the load between them and preserving the stability of their location. Vibrational diagnostics, or the analysis of vibrational parameters, is emerging as one of the most crucial techniques for the entire diagnostics of the bearing's technical condition. According to earlier studies, approximately 40% of machine failures are the result of bearing issues. Because of this, researchers are working to identify the causes of bearing damage as well as novel techniques for detecting damaged bearings. The temperature of the oil film rises in hydrodynamic journal bearings as a result of the oil film being sheared. The lubricant's viscosity decreases due to temperature increase, which in turn reduces the film's ability to support a given load. We have decided to evaluate the performance of a journal bearing configuration with two different lubricants for different loads and speeds based on the vibration patterns collected from an accelerometer, however other parameters can also be employed.

1.1 Literature Survey

(Scott, 2005) defines about journal bearings and their lubrications. A shaft or journal that rotates freely within a supporting metal sleeve or shell is what makes up journal or plain bearings. (Sayed & El-Sayed, 2022) introduces a brand-new technique for measuring nonlinear bearing forces. To assess the bearing forces as a function of the journal centre location, the method relies on polynomial surface fitting. (B et al., 2020)assessed the performance properties of bearings under various operating circumstances. On a phosphorous bronze hydrodynamic journal bearing with a textured surface under various loading situations with multi-grade oil as lubricating at various constant rotating speeds, experimental studies are conducted.(ZHOU et al., 2021) says the prediction of dynamic behaviour of rotor-bearing systems can also be done using the dynamic features and journal orbits. (Reddy & Srinivas, 2016) presents the modelling and dynamic analysis of an on-board rotor with base excitation. For the perfect turbocharger rotor, a flexible shaft and rigid disc model is taken into consideration. The discretized equations of motion are solved using the finite element method, and the nonlinear hydrodynamic journal bearing forces are calculated.(Zhou et al., 2022) compares the computed results provided by the mixed technique with those derived using the Finite Difference Method (FDM). Further study is conducted on the equilibrium position and internal pressure as a function of diameter, lubricant viscosity, and external load. (He et al., 2016) analyses the spherical fixed ring journal bearing's stress using the Fang contact model. The more concentrated the contact zone is, the higher the corresponding contact pressure will be. (Bhattacharjee et al., 2020) reviews on the impact of various lubricants on the functionality of various bearings has been done in this paper. Because each lubricant has advantages and disadvantages for different types of bearings, choosing the right lubricant is essential for the effective operation of a bearing. (Tiboni et al., 2022) provides a thorough analysis of the works on condition monitoring of the rotating machinery on the basis of vibration. The preliminary phase entails an analysis of the publication distribution, to identify the interest in the investigation of the main phases of the diagnostic process, to identify the techniques primarily used for each individual phase of the process, to understand what the interest was in studying the application of the method to the various rotating machineries.(Marey et al., 2018) provides experimental research results for the enhancement of journal bearing boundary lubrication behaviour. The test rig unit can be utilised for many different journal bearing lubrication studies, including bearing material composition, lubricant additives, speed variation, and bearing geometry analysis. In (Simmons, 2013) a journal bearing test machine was built for investigation to look into several novel synthetic lubricants and polymer bearing materials. This testing revealed that switching from a conventional mineral oil to a high viscosity index oil with a much lower base viscosity grade could significantly reduce power loss without materially impacting the bearing's minimum film thickness. (Baskar, 2012) examines how pressure is distributed on a hydrodynamic journal bearing when using various lubricants, loading scenarios, and operating parameters. In the test rig, vegetable oils including rapeseed oil and soya bean oil were put through the same operational tests as the SAE 20W40, and the results were compared.(Omer et al., n.d.) looked into and reported on the effects of additives on base lubricants with the goal of enhancing and improving the performance of hydrodynamic journal bearings. According to the findings, the pressure distribution increased as the volume percent of the additives increased. (Wang et al., 2018) investigates, the lubrication behaviour of journal bearings with various types of evenly dispersed micro-spherical textures. Analysis and discussion are conducted about the impact of geometrical parameters (such as texture depth and area density) on the bearing's load capacity and friction coefficient.

2. COMPONENTS

2.1 Journal bearing apparatus

The journal bearing apparatus consists of a journal bearing connected to an electric motor using a shaft, the journal bearing is connected with manometer tubes in order to find the pressure distribution. The tubes are installed in the housing of the journal bearing at an angle of 60° between each tube. The shaft is connected to a load hanger in which additional load blocks can be added. It also contains a speed controller in order to change the speed.

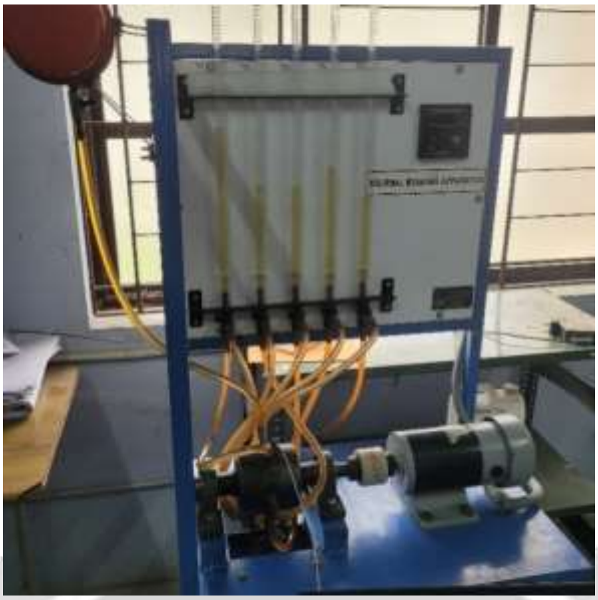


Fig-1: Journal Bearing Apparatus

2.2 Journal Bearing

A hydrodynamic journal bearing is a type of bearing that uses the lubricant, usually oil or water, to create a thin film between the bearing surface and the shaft. This film acts as a cushion, allowing the shaft to rotate smoothly and with minimal friction.

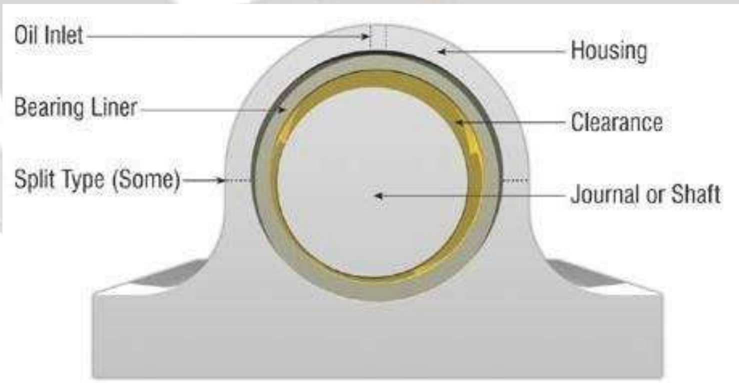


Fig-2: Components of Journal Bearing

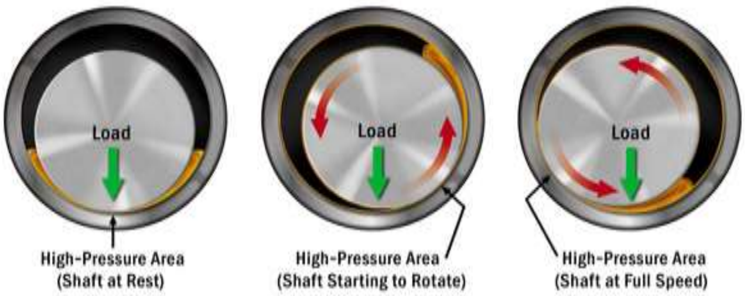


Fig-3: Position of Journal at different stages

2.3 Accelerometer

An accelerometer is a device that measures acceleration, or the rate of change of velocity over time. It is often used in applications where it is necessary to measure the acceleration of an object or system in order to understand its behaviour or to control it. These sensors convert the mechanical motion of the accelerometer into an electrical signal, which can be measured and analysed using appropriate instrumentation.

Fig-4: Accelerometer

2.4 Dynamic Signal Analyzer

Dynamic signal analysers are specialized instruments used to measure and analyse the dynamic behaviour of mechanical, electrical, and other systems. They are commonly used in a variety of fields, including engineering, manufacturing, research, and quality control.

Fig-5: Dynamic Signal Analyzer

2.5 Lubricants

20W-40 Oil

In the case of 20W40 oil, the "20" indicates that it has a viscosity similar to a oil with a viscosity of 20 at low temperatures (-20 degrees Celsius or -4 degrees Fahrenheit), and the "40" indicates that it has a viscosity similar to a oil with a viscosity of 40 at high temperatures (100 degrees Celsius or 212 degrees Fahrenheit). This type of oil is suitable for use in a wide range of applications and environments, including automobiles, motorcycles, and other internal combustion engines.

Table-1: Properties of 20W-40 oil

Property	
Viscosity at 40° C(cSt)	38.44
Viscosity Index	135
Density at 15°C(kg/m³)	904
Pour Point(°C)	-24
Flash Point(°C)	220

Spin 22

Spindle oil is a type of lubricant specifically designed for use in spindles, which are rotating shafts that support and hold workpieces or objects. Spindle oil is formulated to provide the necessary lubrication and protection for spindles, helping to reduce friction, wear, and heat generation. It is typically used in a variety of applications, including machine tools, precision instruments, and other equipment that use spindles.

Table-2: Properties of Spin 22 oil

Property	
Viscosity at 40° C(cSt)	20-24
Viscosity Index	90
Density at 15°C(kg/m³)	860
Pour Point(°C)	-3
Flash Point(°C)	160

3. EXPERIMENTAL SETUP

The experimental setup used for determining pressure heads and vibration data is illustrated below.

Fig-6: Experimental Setup

4. RESULTS AND DISCUSSION

4.1 Pressure Distribution

4.1.1 Pressure Distribution for Spin 22

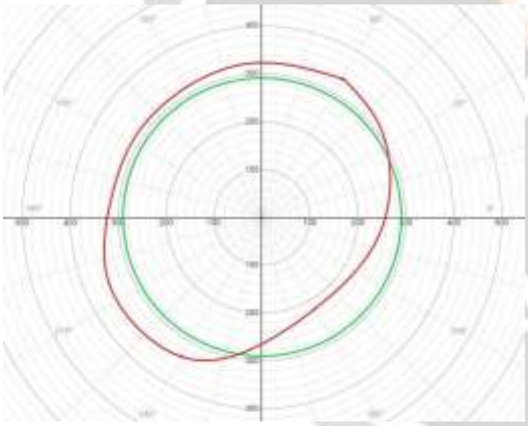
Table-3: Pressure heads (manometer readings) for 500rpm speed at different loads (spin 22)

Tube	Self-weight (mm)	Self-weight+2kg (mm)	Self-weight+4kg (mm)	Self-weight+6kg (mm)
1	335	320	310	375
2	255	245	234	273
3	220	212	182	202
4	335	312	293	305
5	325	310	296	296

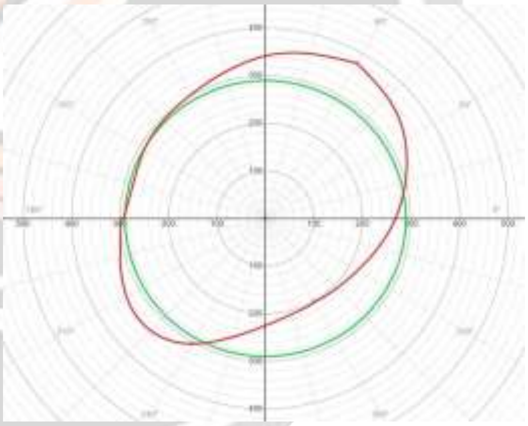
Table-4: Pressure heads (manometer readings) for 1000rpm speed at different loads (spin 22)

Tube	Self-weight (mm)	Self-weight+2kg (mm)	Self-weight+4kg (mm)	Self-weight+6kg (mm)
1	340	422	438	398
2	190	251	265	221
3	147	165	168	144
4	315	345	360	310
5	270	284	300	270

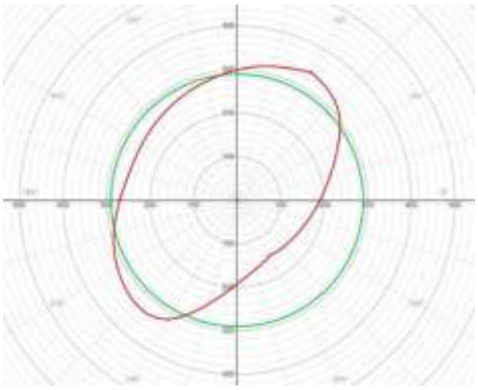
Pressure Profiles



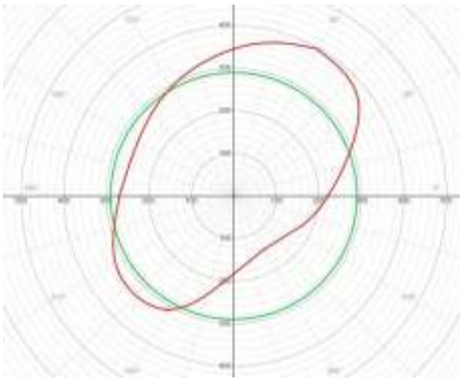
Pressure distribution for 500 rpm and no additional load (Spin 22)



Pressure distribution for 500 rpm and 6kg load (Spin 22)



Pressure distribution for 1000 rpm and no additional load (Spin 22)



Pressure distribution for 1000 rpm and 6 kg load (Spin 22)

4.1.2 PRESSURE DISTRIBUTION FOR 20W-40

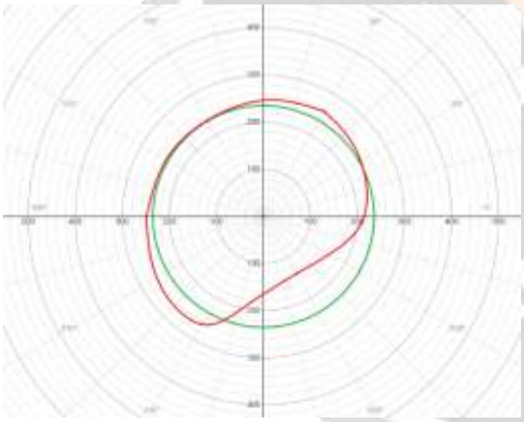
Table-5: Pressure heads (manometer readings) for 500rpm speed at different loads for 20W-40

Tube	Self-weight (mm)	Self-weight+2kg (mm)	Self-weight+4kg (mm)	Self-weight+6kg (mm)
1	258	247	242	238
2	214	210	205	197
3	141	137	131	122
4	263	266	271	272
5	251	243	238	232

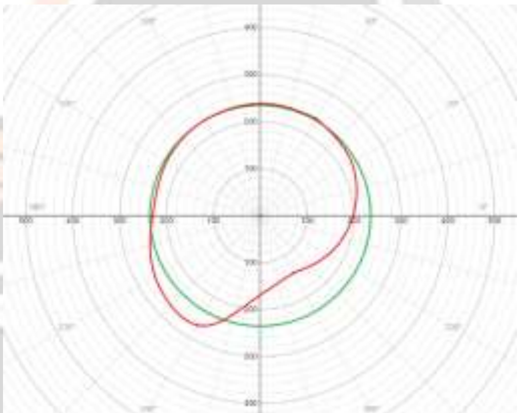
Table-6: Pressure heads (manometer readings) for 1000rpm speed and different loads for 20W-40

Tube	Self weight (mm)	Self weight+2kg (mm)	Self weight+4kg (mm)	Self weight+6kg (mm)
1	283	296	301	312
2	174	214	238	242
3	108	104	100	98
4	265	272	278	281
5	238	244	251	256

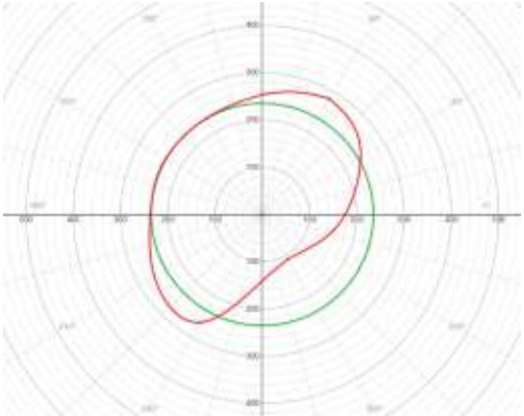
Pressure Profiles



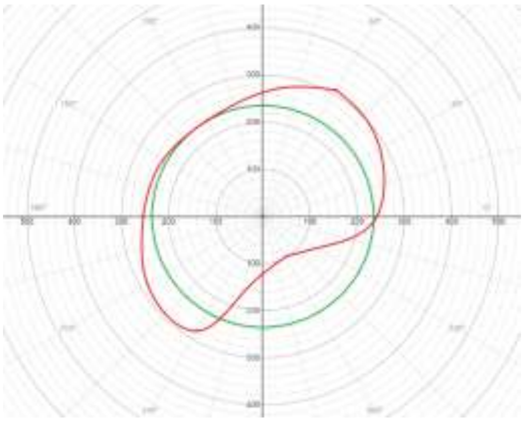
Pressure distribution for 500 rpm and no additional load (20W-40)



Pressure distribution for 500 rpm and 6kg load (20W-40)

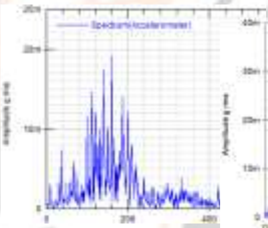


Pressure distribution for 1000 rpm and no additional load (20W-40)

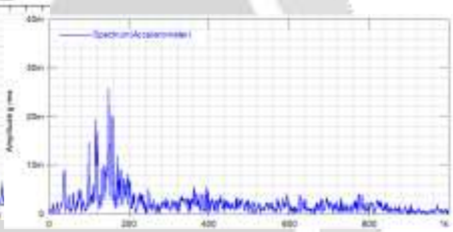


Pressure distribution for 1000 rpm and 6kg load (20W-40)

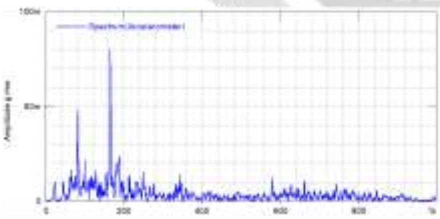
4.2 Vibration Analysis



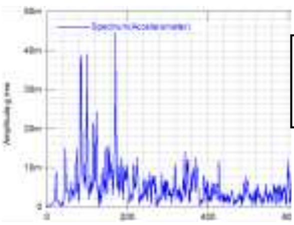
Vibration spectrum for 500 rpm, under self-weight(spin 22)



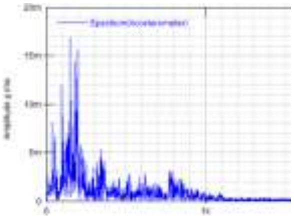
Vibration spectrum for 500 rpm, under 6 kg load (spin 22)



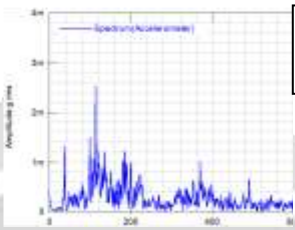
Vibration spectrum for 1000 rpm, under self-weight (spin 22)



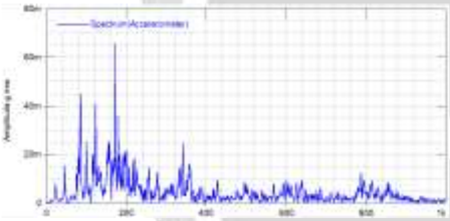
Vibration spectrum for 500 rpm, under 6kg load (spin 22)



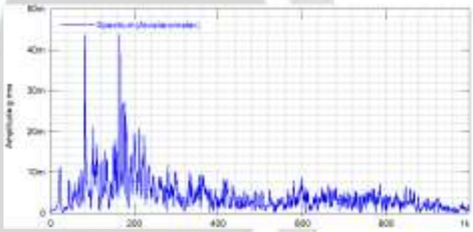
Vibration spectrum for 500 rpm, under self-weight (20W-40)



Vibration spectrum for 1000 rpm, under self-weight (20W-40)



Vibration spectrum for 1000 rpm, under self-weight (20W-40)



Vibration spectrum for 1000 rpm, under self-weight 20W-40)

Table-7: Vibration Spectrum for Spin 22

Load condition	Frequency (Hz)	Amplitude (g rms)
500 rpm, no load	1.61E+02	1.92E-02
500 rpm, 6 kg load	1.50E+02	2.56E-02
1000 rpm, no load	1.66E+02	8.00E-02
1000 rpm, 6 kg load	1.71E+02	4.45E-02

Table-8: Vibration Spectrum for 20W-40

Load condition	Frequency (Hz)	Amplitude (g rms)
500 rpm, no load	1.50E+02	1.69E-02
500 rpm, 6 kg load	1.14E+02	2.52E-03
1000 rpm, no load	1.72E+02	6.57E-02
1000 rpm, 6 kg load	1.66E+02	4.38E-02

5.4 Conclusion

Two different lubricants (spin 22 and 20W-40) are chosen and analysed based on the performance of journal bearing under different loading conditions and speeds by observing the pressure profile and vibration spectrums obtained. Based on the results we have inferred that for this journal bearing 20W-40 oil gives off relatively lesser vibration than spin 22 oil and also while observing the pressure profiles, 20W-40 performs better than spin 22(as it shows lesser deviation from initial reading). When it comes to vibration at higher speed and load both the oils perform almost similar to each other, but the pressure profile varies greatly. It is also observed that at certain points abnormal readings are observed in the pressure profile. This occurs as the frequency of vibration matches the natural frequency of the oil making it to lose its natural lubrication properties.

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