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CFD ANALYSIS OF THE EFFECT OF CONSTANT AND VARYING DEPTH DIMPLES TEXTURED SURFACE ON THE PERFORMANCE OF HYDRODYNAMIC JOURNAL BEARING: A REVIEW

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Abstract

A Journal bearing is one of the most crucial components required to sustain rotating shafts in heavy machinery. It is subjected to abrasion from the shaft and must support heavy weights. Thus, it requires extensive lubrication to lessen wear and friction. The hydrodynamic journal bearing is one of the most affordable and effective machine components, used to support the rotating shaft. It doesn't require any external mechanisms to maintain lubrication pressure along the shaft's periphery. In a hydrodynamic journal bearing, the viscosity of the lubricant is crucial. Due to viscosity, the lubricant becomes sticky to the shaft's and the bearing's surface. The aim of the study to read various literature and find the gap between various analysis or research have been done in journal bearing and find the problem statement to improve the performance of journal bearing with varying its parameters.

Keywords: Journal Bearing, CFD, ANSYS, Lubricant, Rotating Shaft.

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1. Introduction

With hydrodynamic bearings, the bearing movement actively creates the gap. In order to prevent excessive friction upon initiating rotation, hydrodynamic bearings used in rotary applications may need external pressure applied to one of the bearing pads or a secondary bearing. Oftentimes, hydrodynamic bearings are made to handle thrust or radial stresses. A hydrodynamic bearing is often a low-clearance component that relies on an oil film—and occasionally air—that creates a room as the spindle rotates. The lubricant film's self-renewing load is lifted by the bearings.

Journal bearings are the most fundamental hydrodynamic bearing. Its bore resembles a tube and often has two axial lubricating grooves. This bearing has a large load capacity, making its straightforward design small, bi-rotational, and simple to produce. Viscosity is strongly influenced by temperature; viscosity lowers as temperature rises and vice versa. The lubricant is drawn to the area of sliding contact between the surfaces of the shaft and bearing as the journal starts to rotate. In essence, the journal serves as a lubricant pump. As the journal rotates more quickly, a wedge action arises between the journal and the bearing, lifting the journal and separating it from the bearing surfaces.

Circumferential groove bearings, pressure bearings, and multiple groove bearings are the three fundamental types of hydrodynamic bearings. Spindles with hydrodynamic bearings are used for precise machining and finishing because they have a high degree of rigidity and long bearing life.

Machines with hydrodynamically oiled/greased bearings shouldn't endure/be able to handle the heavy load at first. Industrial applications include steam turbines, electric motors, cooling pumps, and rock crushers frequently use hydrodynamic bearings. Blowers, pumps, and auxiliary equipment are frequently seen on ships and used in limited space. In a hydrostatic bearing, a source of pressured fluid from the outside drives oil or grease between two surfaces, allowing for non-contacting operation and the capacity to carry weight. Large loads can be supported without journal rotation using hydrostatic bearings, which also offer significant direct stiffness and damping coefficients.

Figure 1. Hydrodynamic Bearing

Even in the absence of journal rotation, hydrostatic bearings rely on external fluid pressurization to provide load support and significant centering stiffness. Hydrostatic bearings are the appropriate rotor support components in process fluid pumps because their load capacity and direct stiffness are independent of the fluid viscosity. In current applications, two bearings will combine to replace the oil-lubricated bearing in order to increase efficiency with smaller rotor spans and fewer mechanically challenging issues. The hydrostatic bearings used by today's cryogenic liquid turbo-pumps allow for an all-fluid film-bearing technology with a very small part count and no DN limit operating.

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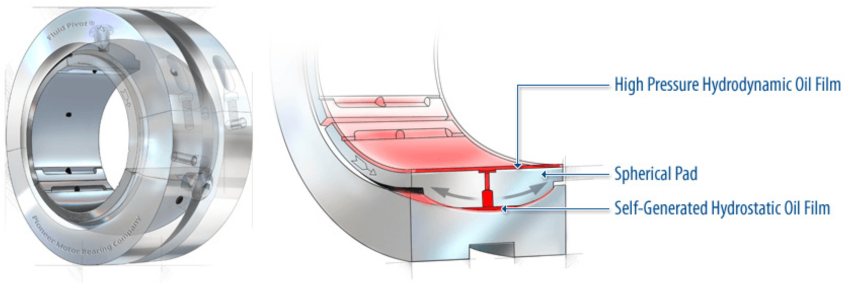

Figure 1. Hydrostatic Bearing

Various types of machinery use journal bearings, a type of mechanical bearing, to support rotating shafts or journals. The rotating shaft and stationary bearing surface will experience less friction thanks to the journal bearing, which enables the shaft to rotate smoothly and with little wear. The journal or shaft, which rotates, and the bearing surface or sleeve, which is stationary, make up the journal bearing. In order to lessen friction and wear on the rotating shaft, the bearing surface is typically made of a low-friction material, such as bronze or Babbitt. An overview of pins and bushings, dry and semi-oiled/greased journal bearings, and tilting-pad bearings are provided before turning the focus of this article to oil and grease-lubricated full fluid film journal bearings. A type of bearing in which the shaft or shell typically doesn't complete a full revolution is called a low-speed pin and bushing. Metal-to-metal contact does occur within the bearing as a result of the partial rotation at low speed, which typically reverses direction before stopping. Pins and bushings function continuously within the effective edge-related lubrication regime.

2. Literature Review

Various papers related to the journal bearing's surfaces are read and evaluated to get a brief overview of previously done work and strategies involve.

(S Cupillard,,S Glavatskih, and M J Cervantes) The coefficient of friction can be reduced by providing suitable texture or dimples exactly within the area of the highest possible hydrodynamic pressure for a bearing with a high weirdness ratio or just downstream to it where the oil/grease film thickness is maximum for a bearing with a low weariness ratio.

(Fredrik Sahlin, Sergei B. Glavatskih, Torbjo¨rn Almqvist, Roland Larsson) The load-carrying capacity of the bearing can be improved by introducing micro-pattern surfaces in a hydrodynamic journal bearing.

(P. Brajdic-Mitidieri, A. D. Gosman, E. Ioannides, H. A.) Spikes performed an analysis that shows that the pressure of closed pockets in bearings can result in a significant reduction in bearing friction coefficient.

(Tomoko Hirayama, Takeo Sakurai, and Hiroshi Yabe) investigated the performances of an oil-lubricated spiral-grooved journal bearing with special attention paid to cavitation occurrence. The ''equivalent flow model,'' which was a theoretical scheme for taking the cavitation occurrence into hydrodynamic lubrication theory, was applied to the analyses by a finite difference treatment of the Reynolds equation that deals with the geometry of a finite number of grooves.

Zhang et al. (2016) investigated how attitude angle affected journal bearings with dimples' hydrodynamic performance and discovered that raising the attitude angle could increase the bearings' ability to support more weight.

Hu et al. (2018) performed a numerical analysis of the impact of dimple diameter and spacing on the tribological behaviour of journal bearings and discovered that a combination of larger diameter and smaller spacing can improve load-carrying capacity while lowering frictional force.

Li et al(2019), investigation into the impact of dimple shape on journal bearing performance revealed that triangular-shaped dimples significantly outperform circular-shaped dimples in terms of the hydrodynamic performance of the bearings.

Liu et al. (2021), who looked at how the starting angle of dimples affected the tribological behaviour of journal bearings, starting the dimples from a particular angle can enhance the hydrodynamic performance of the bearings.

(S Cupillard,S Glavatskih, and M J Cervantes) The coefficient of friction can be reduced by providing suitable texture or dimples exactly within the area of the highest possible hydrodynamic pressure for a bearing with a high weirdness ratio or just downstream to it where the oil/grease film thickness is maximum for a bearing with a low weirdness ratio.

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Lubricants viscosity is a very important role in hydrodynamic journal bearing which can be used to change the operating characteristic (Hydrodynamic Lubrication In Tribology Series, 1990).

Balakrishnan, ... H. Rahnejat, in Tribology and Dynamics of Engine and Powertrain, 2010.Temperature can reduce the viscosity of the lubricant and due to this, the film thickness reduces between the journal and the bearing and so higher pressure is created. This also results in a higher weariness ratio and because of this increases the load-carrying capacity of the bearing.

3. Conclusion

As we can see from a review of the literature, the usage of dimples on the journal bearing's surfaces has drawn a lot of interest because of their potential to enhance the bearings' functionality. Dimples, which are tiny, circular depressions on the bearing surface, can change the lubricant's flow pattern and provide hydrodynamic pressure, which supports weight and lowers friction. The effects of other design factors, such as dimple depth, attitude angle, starting angle of dimples, and span of dimple, have not been thoroughly investigated. While the influence of dimple geometry, such as diameter and spacing, has been researched in the past. These design considerations are essential because they have a big impact on how well journal bearings with dimples operate hydrodynamically.
The frictional force and load-carrying capability of journal bearings with dimples must therefore be thoroughly studied to determine the implications of key design parameters, including dimple depth. In particular, it is

necessary to investigate how changing the dimple depth affects the tribological behaviour of journal bearings while maintaining a fixed dimple width. Also, it is necessary to assess how dimple depth affects the creation and maintenance of lubrication film, as well as how it affects the hydrodynamic pressure and load-bearing capability of the bearings.

To maximize the frictional force and load-carrying capability of journal bearings while taking into account the limitations of the manufacturing process and the practical applications of the bearings, the ideal dimple depth must also be established. Lastly, in order to provide a more thorough understanding of the performance of these bearings, it is necessary to investigate the interaction effects among various design factors and their impact on the tribological behaviors of journal bearings with dimples. This study attempts to fill these knowledge gaps and offer information on how journal bearings with dimples might be optimized for a variety of uses.

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