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OPTIMUM DESIGN OF JOURNAL BEARING THROUGH SURFACE TEXTURING - A REVIEW

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ABSTRACT:

Hydrodynamic journal bearings are machine elements commonly used in all mechanical systems with rotating shaft subjected to high surface speed and/or applied load for the support of rotating shaft since the beginning of industrial revolution. With an aim of bringing improvements in different bearing performance parameters researches have suggested various design improvements. Incorporation of different shapes of textures on journal and/or bearing at different location of texture zone is reported to have significance influence on the bearing performance. Different types of surface roughness / texturing has been proposed and evaluated for this purpose. Rather, the selected pattern and arrangement of features must be matched to characteristics of the proposed application, bearing materials, and lubricants. Constraints are imposed on the maximum fluid pressure, minimum film thickness, maximum temperature rise and critical speed. Here a brief review is presented of literature available in recent years.

KEYWORDS: JOURNAL BEARING; SURFACE TEXTURE; COEFFIUCIENT OF FRICTION; LOAD CARRYING CAPACITY; MINIMUM OIL FILM THICKNESS.

INTRODUCTION

Hydrodynamic journal bearings are machine elements commonly used in different application ranging from small automobile engines to large turbines employed in power generating unit. 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. Hydrodynamic lubrication in general bearing is defined as a system of lubrication is created by shape and relative motion of sliding surfaces. In this case there is thick film of lubricant between journal and bearing little consideration will show that when bearing is supplied with sufficient lubricant a pressure is build up in the clearance space when journal is rotating about an axis that is eccentric with bearing axis as shown in fig 1. The load can be supported by this fluid pressure without any actual contact between the journal and the bearing. The load carrying ability of a hydrodynamic bearing arises because of simply because a viscous fluid resists being pushed around.

The study of the effects of bearing surface texture on the bearing performance and loads is an effective approach for the optimization of the bearing. It helps in effective lubrication and thus it optimizes the bearing performance.

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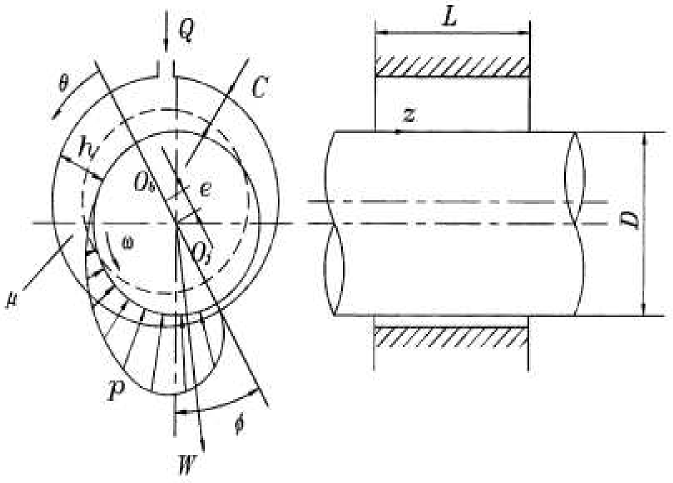

Figure 1

In tribology, the four basic functions of texturing are:

(i) To alter the flow and film thickness of lubricating fluids locally and across the contact region,

(ii) To serve as channels to supply lubricant to a surface

(ii) To trap debris that would otherwise become embedded or abrade the surfaces, and

(iii) To alter the bearing pressure distribution.

Various researchers have presented a unique technique of designing the parameters of journal bearing. However with recent advances in technologies numbers of researchers have worked on optimum performance of bearing. The present study mainly focuses on various types of factors which tremendously affects the performance of hydrodynamic journal bearing. To simplify the review papers are classified into following parameters:

Coefficient of friction

[Adatepe *et al*, (2011)] The effects of different interface friction conditions on the frictional performances of the plain and the micro-grooved journal bearings have been shown in this paper. The purpose of this research was therefore, to experimentally and theoretically investigate and to compare the frictional behavior of the concentric circular cylindrical non-grooved (plain) and micro-grooved journal bearings. In order to accomplish this objective, the plain surface bearings were first tested under different loads and rotational speeds. Circumferential (circular) and transversal (straight) grooves were then made on to the plain engine journal bearings and the tests were then repeated for the circumferential and transversal micro-grooved bearings by using the same bearing parameters. In this research, the frictional behavior of plain and micro- grooved journal bearings were investigated and compared using a purpose-built journal bearing test rig. The work presented in this paper leads to the following conclusions:

The highest value for the coefficient of friction was obtained for the transversal micro-grooved journal bearing, followed by the circumferential micro-grooved journal bearing, and the plain journal bearing. The coefficient of the friction of the micro-grooved journal bearings decreased with the increasing bearing load as in the theory of plain journal bearing The maximum value for the frictional torque was determined for the transversal micro-grooved journal bearing, followed by the circumferential micro-grooved, and the plain journal bearings, as for the coefficient of friction [1].

[Rao *et al*, (2012)] This paper presents one-dimensional analysis of partially textured slip slider and journal bearing. The present study evaluates the effects of texture/slip configuration on improvement in load capacity and reduction in coefficient of friction for partially textured slip slider and journal bearing. The texture/slip parameters used in the analysis are: non dimensional texture length; non dimensional depth of recess/groove; land with slip to recess region ratio; number of cells; and non dimensional slip coefficient. The analysis of partially textured slip slider and journal bearing is carried out using modified classical Reynolds equation.

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Bearing surfaces with partially textured slip has a potential to generate load carrying capacity even for parallel slider bearing and concentric journal bearing [14].

[Pettersson and Jacobson, (2003)] In the present paper, well-defined surface textures were produced by lithography and anisotropic etching of silicon wafers. The wafers were subsequently PVD coated with thin wear resistant TiN or DLC coatings, retaining the substrate texture. In this study, the influence of textures was investigated on PVD coated TiN and DLC (diamond-like Carbon) surfaces. The use of high precision anisotropically etched silicon surfaces as a substrate minimizes the influence of coarse edges and other unintended topographical features.

For case of tin coated surface the textured surfaces wear the steel ball more than the un-textured ones. When lubricated, the low friction conditions last shorter on textured surfaces than on the flat ones. For case of DLC coated surface under the boundary lubricated conditions, a few of the textured DLC surfaces exhibited excellent performance. The flat surface, the 50 μm textures and the one interrupted by 20 μm square depressions could not keep the low friction and they suffered severe wear. The 5 and 20 μm grooved textures and the surface with 5 μm depressions exhibited a friction coefficient of around 0.05 that kept constant during all the 200,000 cycles [12].

Load carrying capacity

[Buscaglia *et al*, (2007)] In the present study the authors have analyzed the effect of 1D and 2D textures of period $\varepsilon<<1$ on thrust bearings is investigated theoretically by means of homogenization techniques and first-order perturbation analysis. The (positive, uniform and periodic) texture that maximizes the load-carrying capacity is, simply, no texture at all [2].

[Kango and Sharma, (2010)] In this study authors have used positive full wave rectifier equation to analyze influence of asperities on performance of finite bearing. A range of eccentricity ratios provide improvement in hydro dynamic performance of journal bearing with surface texturing. The increase asperity amplitude ratio provides much improvement in bearing performance. This may be fruitful in increasing load carrying capacity and reducing the friction coefficient and also power loss of bearing [9].

[Cupillard *et al*,] A mesh deformation technique is used with CFD (COMPUTATIONAL FLUID DYNAMICS) in order to perform the simulations. The flow is laminar, isothermal, three dimensional (3D) and unsteady. It is found that shallow grooves under light loading ($\varepsilon < 0.15$) enhance the minimum film thickness while reducing the friction force. Under high loading ($\varepsilon > 0.5$), deep grooves are able to reduce the friction force despite a reduced minimum film thickness. For the second case, the predicted performance is superior to those of a smooth journal bearing with thinner lubricant [4].

Minimum oil film thickness

[Tala-Ighil *et al*, (2011)] In the present paper the author has analyzed the effect of textured area on the performance of hydrodynamic journal bearing by texturing the bearing surface with cylindrical dimples. A numerical model based on finite difference method by using Reynolds equation is developed to study the cylindrical textures shape effect on the performance of hydrodynamic journal bearing. Twenty five cases according to the geometric arrangement of textures on the bearing surface have been considered. The texture configuration twenty five gives the best result compared with all the other cases, the minimum oil film thickness increased approximately by 1.8% and friction torque is decreased approximately by 1.0%. The analysis also shows that performance of journal bearing depends on location of texture geometry. [8].

[Cho *et al*, (2000)] In the present study the effects of circumferential groove on the minimum oil film thickness in engine bearings are presented. Infinitely short bearing theory is used to calculate the oil film pressure for the convenience of analysis. Mobility method is used for journal locus analysis. A comparison of results of

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minimum oil film thickness (MOFT) of grooved and un-grooved bearing is made. It is observed that the circumferential 360^0 groove only decreases the magnitude of the MOFT, but 180^0 half groove affects the shape and position of the MOFT [8].

Artificial intelligence techniques

[Dongare and Kachare, (2012)] In this paper experimental, theoretical and analytical approach has been carried out at variable speed, load, torque and temperature to investigate pressure distribution of steel shaft of hydrodynamic journal bearing. Experimental work has been done on journal bearing test rig and simulation has been done with implementation of ANN which shows close result with experimental pressure distribution. This technique can be used to predict the behavior of hydrodynamic journal bearing at extreme operating condition to avoid failure[6].

CONCLUSION:

The highest value for the coefficient of friction was obtained for the transversal micro-grooved journal bearing. The maximum value for the frictional torque was determined for the transversal micro-grooved journal bearing. Bearing surfaces with partially textured slip has a potential to generate load carrying capacity even for parallel slider bearing and concentric journal bearing. For case of tin coated surface the textured surfaces wear the steel ball more than the un-textured ones. For case of DLC coated surface a few of the textured DLC surfaces exhibited excellent performance. Under light loading $\varepsilon < 0.15$ shallow grooves enhance the minimum film thickness while reducing friction force; under high loading $\varepsilon > 0.5$ deep grooves are able to reduce frictional force despite a reduced minimum film thickness. Partial texturing can generate hydrodynamic lift in bearing, when the texture is located in the declining part of the contact pressure field.

References

[1] Adatepe, H; Bıyıklıoglu, A; Sofuoglu, B. (2011): An experimental investigation on frictional behavior of statically loaded micro-grooved journal bearing, J. Tribology International 44, pp. 1942–1948.
[2] Buscaglia, G.; Ciuperca, I.; Mohammed, J. (2007): On the optimization of surface textures for lubricated contacts, J. Math. Anal. Appl. 335, pp. 1309–1327.
[3] Cem Sinano˘glu , Fehmi Nair, M. Baki Karamıs (2005) ;Effects of shaft surface texture on journal bearing pressure distribution, J. of material processing technology 168,pp.344-353.
[4] Cupillard, S; Cervantes, M.; Sergei Glavatskih, S. (A CFD STUDY OF A FINITE TEXTURED JOURNAL BEARING IAHR 24th Symposium on Hydraulic Machinery and Systems.
[5] Das N. C., (1999);A Study of Optimum Load Capacity of Sliding Bearings Lubricated with Power Law Fluids, J. Tribology International, Vol.32, Issue 8, Pages 435-441.
[6] Dongare, A ; Kachare, A. (2012):Predictive Tool: An Artificial Neural Network, (IJEIT), Volume 2, Issue 1, July 2012, ISSN: 2277-3754
[7] Hashimoto, H., (1998);Optimization of Oil Flow Rate and Oil Film Temperature Rise in High Speed Hydrodynamic Journal Bearings, J. Tribology Series 34, pp. 205-210
[8] Ighil, N.; Fillon, M.; Maspeyrot, P. (2011): Effect of textured area on the performances of a hydrodynamic journal bearing, J. Tribology International 44, pp. 211–219.
[9] Kango, S.; Sharma, R. (2010):Studies on the influence of the positive roughness on the performance of journal bearing”, J. Tribology and surface engineering, Volume 1,Issue3/4, ISSN:1949-4866
[10] Myung-Rae, C.; Hung-Ju, S. and Dong-Chul, H. (2000): A study on the circumferential groove effects on the minimum oil film thickness in engine bearings”, KSME International Journal 14, pp. 737-743.
[11] Nagaraju T., Sharma S., Jain S., Influence of Surface Roughness Effects on the Performance of Non recessed Hybrid Journal Bearings, Elsevier, Vol. 2002, pp. 467-487.
[12] Pettersson, U.; Staffan Jacobson, S. (2003): Influence of surface texture on boundary lubricated sliding contacts, J. Tribology International 36, pp. 857–864.
[13] Ramesh, A et al, (2012); Friction characteristics of micro textured surfaces under mixed and hydrodynamic lubrication, J. Tribology International 57,pp. 170–176.
[14] Rao, T et al. (2012): Analysis of slider and journal bearing using partially textured slip surface, J. Tribology International 56, pp. 121–128.
[15] R.S. Khurmi, J.K. Gupta, A Textbook of Machine Design, S. Chand (2008).
[16] Sherbiny, M.E., and Salem F., and Hefnawy, N.E. (1984); Optimum Design of Hydrostatic Journal Bearings Part I: Maximum Load Capacity, J. Tribology International 17, Issue 3, pp. 155-161.
[17] V.B. Bhandari, Design of machine elements, Tata McGraw Hill (2008).