International Journal of Current Engineering and Technology
E-ISSN 2277 – 4106, P-ISSN 2347 - 5161

Available at http://inpressco.com/category/ijcet

Research Article

Analysis on Micro-Elliptical Textured Journal Bearing

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Accepted 10 January 2014, Available online 01 February 2014, **Special Issue-2, (February 2014)**

Abstract

An Analysis is performed on load carrying capacity, friction variable and flow coefficient of micro elliptical textured journal bearing. In which texture density and texture depth are varied for better performance of journal bearing. Here elliptical dimples are used. For different texture depths, different performance characteristics are tested.When texture density and texture portion are concerned, there is increase in load carrying capacity has been observed with increase of texture density or texture portion and further Increase in flow and decrease in friction variable has been observed.

Keywords: *micro elliptical texture, Hydro Dynamic Lubrication, Journal Bearing, Finite Difference Method.*

1. Introduction

Micro dimples are developed manufactured by incremental stamping using a particular type of structured tool. The structured tool is manufactured by focused ion beam sputtering. Interference Lithography also used for producing micro dimples on surfaces.

Study hasbeen done ontwo structured patterns, i.e. checkerboard and sinusoidal dimples**.** The tailored surfaces show a consistent improvement in performance compared to the smooth ones. The effects are, however, less marked than those of the best combinations and macro-geometries (Tonder *et al*, 2004). This beneficial effect is at a maximum for the longest dimples with a length shorter than the pad length (Cupillard *et al*, 2009). An analytical approach to study the textured surfaces has been introduced in hydrodynamic lubrication regime. An optimization procedure is employed to achieve the optimum texturing parameters promoting maximum load capacity, load capacity to lubricant flow rate ratio and minimum friction coefficient for asymmetric partially textured slider bearings (Rahmani *et al*, 2010). Micro fabrication techniques on cylinder surface have been studied and developed (Takashi *et al*, 2012). Some micro dimples on aluminum plates have been developed (Takashi *et al,* 2013). Analysis on 3D inlet textured slider bearing with a temperature dependent fluid has been performed. Results show that texture has a stronger and positive influence on load carrying capacity when thermal effects are considered.

The present work concentrates on performance of textured hydro-dynamic journal bearing.

Nomenclature

C=Clearance (m).
e = Relative eccentricity.
ε = Eccentricity ratio = e/C.
ε_1, ε_2 Dimple aspect ratios for elliptical dimples, $\varepsilon_1 = h_p/2a, \quad \varepsilon_2 = h_p/2b$
h=Film thickness (m).
Δh = Variation of film thickness due to the presence of the texture (m).
$\bar{h} =$ = Dimensionless film thickness.
$\Delta\bar{h}$ = Dimensionless variation of film thickness due to the presence of the texture.

L= Bearing Length (m).
P= Lubricant Pressure (Pa).
$\bar{P} =$ Dimensionless Lubricant Pressure
ΔP = Variation of pressure (Pa).
R= Radius of the bearing (m).
S = Sommerfeld number.
$S_p =$ Dimple area density
U= Linear velocity (m/s).
W= Load carrying capacity (N).
$\bar{W}$ = Dimensionless Load carrying capacity.
x, y, z = Cartesian coordinate system (m).
$\bar{Z}$ = Dimensionless axial coordinate.
ϕ = Attitude angle.
η = Dynamic viscosity (Pas).
θ = Angular coordinate.

2. Placing the figures

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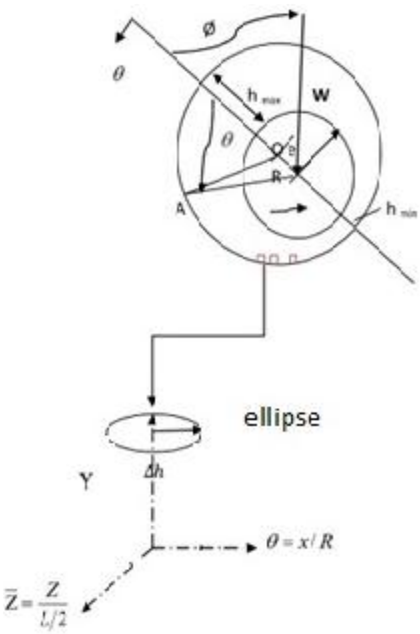


Fig.1 Hydro dynamic journal bearing with elliptical texture.

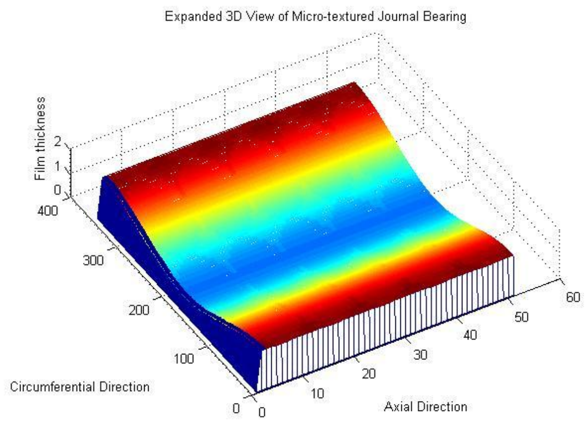
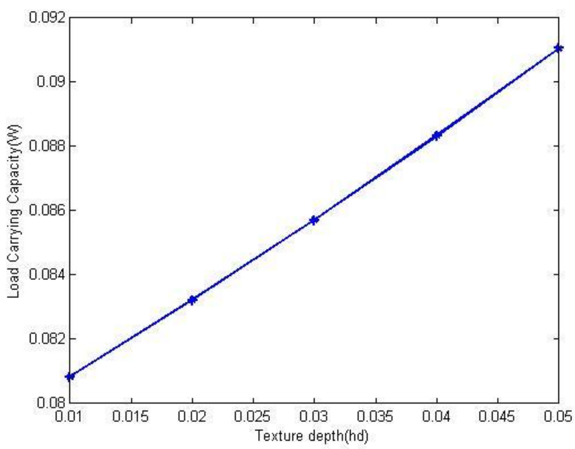


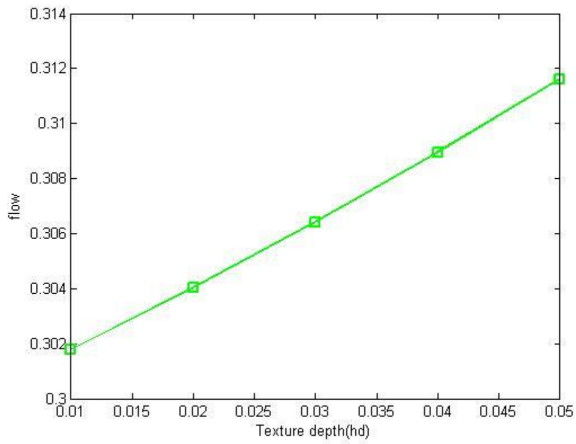
Fig.2 3D view of film thickness for elliptical textured journal bearing.

2.1 Placing the graphs

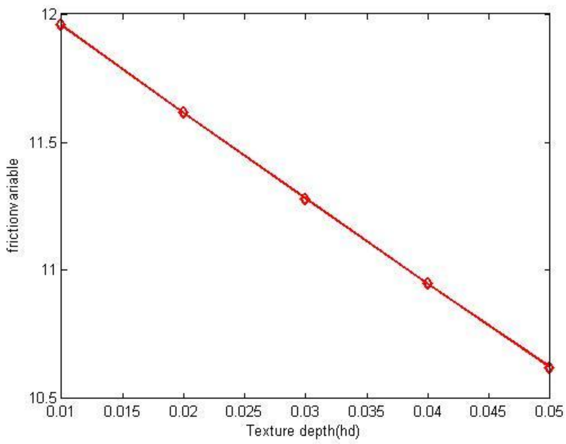


Graph.1 Variation of load carrying capacity with the variation of texture depth

Figure2 represents 3Dimensional view of film height and distribution of elliptical texture on bearing. Figure2 represents Variation of load carrying capacity with the variation of texture depth. Here load capacity increasing with the increase of texture depth. Figure3 and Figure4 represents flow and friction variable respectively. Increase in flow and decrease in friction variable has been observed which indicates texturing has improved bearing performance.



Graph.2 Variation of non-dimensional flow coefficient with the variation of texture depth



Graph.3: Variation of friction variable with the variation of texture depth

2.2 Using and placing the equations

The governing equation can be expressed as

$$\frac{\partial}{\partial x}\left(h^3 \frac{\partial P}{\partial x}\right) + \frac{\partial}{\partial Z}\left(h^3 \frac{\partial P}{\partial Z}\right) = 6\eta U\left(\frac{\partial h}{\partial x}\right) \quad \text{.......} (1)$$

For non-dimensional solution, the substitutions are

$$x = R\theta, \quad \bar{Z} = \frac{Z}{L/2}, \quad \bar{h} = \frac{h}{C}, \quad \bar{P} = \frac{PC^2}{6\eta UR}$$

The film thickness for textured journal bearing h that can be written as follows:

$$h = h_{smooth}(\theta) - \Delta h(\theta, \bar{Z}) \quad \text{.........}(2)$$

The lubricant film thickness $h_{smooth} = C(1 + \varepsilon \cos\theta)$ for smooth bearing (without textures) is dependent upon radial clearance C, eccentricity ratio, and the angular position. In the equation above, $\Delta h\left(\theta,\overline{Z}\right)$ is the film thickness variation due to the textured surface.

The boundary conditions are $\frac{\partial\overline{P}}{\partial\theta}=\frac{\partial\overline{P}}{\partial Z}=0$ and $\overline{P}=0$ at the end limits of the film lubricant.

The total Dimensionless load carrying capacity $\overline{W}$ is calculated by integrating the pressure field along the surface contact of the journal bearing, and then the attitude angle ϕ is obtained.

$$\overline{W}=\sqrt{\left(\int_0^1\int_0^{2\pi}\overline{P}r\cos\theta d\theta d\overline{Z}\right)^2+\left(\int_0^1\int_0^{2\pi}\overline{P}r\sin\theta d\theta d\overline{Z}\right)^2} \quad \cdots\cdots(3)$$

In this work, 350 nodes have been used in θ directionand 50 nodes have been used in Z direction. Length along θ direction is 2π and length along Z direction is 1.

Validation: The present results are non-dimensional, however, non-dimensional analysis of cylindrical textured bearing are not available. Therefore, to validate the code developed, it is proposed to take the operating conditions of Nacer *et.al*.

3. Placing the tables

Operating conditions of journal bearing
Shaft speed U = 19.7 m/s
Shaft radius R = 0.0315m.
Bearing length L = 0.063m.
Radial clearance C = 0.00003m.
Lubricant viscosity η = 0.0035Pa s.

The numerical results on performance characteristics of journal bearing are generated for the journal bearing length to diameter ratio, 1.0 and eccentricity ratio, 0.6 and then the results are converted to dimensional form using the operating conditions mentioned above.

Table1: Comparison of present results with available results

Characteristic	This study	N Tala-Ighil
Load Capacity	12,550 N	12,600 N
Sommerfeld Number	0.1214	0.1210
Eccentricity ratio	0.600	0.601
Attitude angle	50.4	50.4

Conclusions

1). Load carrying capacity of journal bearing is calculated with the variation of texture depth.
2). Full texture improving load carrying capacity about 13.25% while comparing with non-textured bearing
3). There is a maximum load carrying capacity observed at full texture density.
4).When texture density and texture portion are concerned, there is increase in load carrying capacity has been observed with increase of texture density or texture portion.
5) Oil flow increasing with increase in texture depth and density.
6). Friction variable is decreasing, it sense that improvement in bearing performance.

References

B Vincent, P Maspeyrot, J Frene (1994) ‘Starvation and cavitation effects in finite grooved journal bearing’ *Proceedings of the 21st Leeds–Lyon symposium on tribology, lubricants and lubrication, tribology series* 30, pp. 455–64

K Tønder (2004) ‘Hydrodynamic effects of tailored inlet roughness: extended theory’ *Tribology International*, vol.37, pp.137–142

S Cupillard, S Glavatskih, M Cervantes (2009) ‘3D thermo hydrodynamic analysis of a textured slider’ *Tribology International*, vol.42, pp.1487–1495

R Rahmani, I Mirzaee, A Shirvani, H Shirvani (2010) ‘An analytical approach for analysis and optimization of slider bearings with infinite width parallel textures’ *Tribology International*, vol. 43, pp.1551–1565.

N Tala-Ighil, M Fillon, P Maspeyrot (2011) ‘Effect of textured area on the performances of a hydrodynamic journal bearing’ *Tribology International*, vol.44, pp. 211–219

M Takashi, I Fumio, H Takuya, Y Masahiko (2012) ‘Micro machining for control of wettability with surface topography’ *Journal of Materials Processing Technology*, vol.212, pp.2669– 2677.

M Takashi, S Hitoshi, M Hiroshi, Y Masahiko (2013) ‘Micro fabrication on cylinder surface for control of wettability’ *Journal of Manufacturing Processes*, vol.15,pp. 8–13.