Hydrodynamic Lubrication of Textured Porous Journal Bearing: A Review

Ashish Kumar, Dinesh kumar

Department of Mechanical Engineering, Sri Sai Group of Institutes Badhani – 145001 (Punjab)

Abstract - The progress on various aspects of hydrodynamic lubrication of porous journal bearings is reviewed, from recent research we find that, Non-Newtonian fluids replace the Newtonian completely numerical results show that non-Newtonian fluid models significantly improve the load carrying capacity (W) and reduce coefficient of friction (COF). The texturing is helpful to increase the load carrying capacity of the bearing but some particular type of the textures gave us use good results some researches provide us more interesting fact that rather than full textured surfaces partial textured surfaces provide more good results, in partial type of texturing cost and time both are saved It has also been observed for surface texturing that configuration gives optimum results for both load carrying capacity as well as COF, when compared with all other configurations

Keywords: Hydrodynamic Journal Bearing Lubrication and Texturing Review.

INTRODUCTION

Porous metal bearings have been in use since 1925 [l] and are increasing in popularity because of their flexibility and low cost. Their use by machine designers is exemplified by the fact that in 1970 about 20 million porous bearings entered service daily [2]. Scientific investigation began in the 1950s the number of published papers on various aspects of porous journal bearings. The first analytical study of porous bearings operating under hydrodynamic conditions was made by Margon and Cameron [3]. **A.** Cameron, V. T. Morgan in 1961, Porous Metal Bearings consists of a bearing bush made of porous sintered metal. The pores of this matrix are impregnated with oil, which is some 30 per cent of the volume of the part, and this oil serves as a lubricant throughout the life of the bearing. [4] There have been numerous studies on various types of porous bearings [5–8]. These authors have considered the lubricant as a Newtonian fluid. But the Newtonian fluid constitutive approximation is not a satisfactory engineering approach to many lubrication problems. Hence, the use of non-Newtonian fluids as lubricants has gained importance in the modern industry. The experimental results show that the addition of a small amount of a long-chain polymer solution to a Newtonian fluid gives the most desirable lubricant. A number of micro continuum theories have been developed to explain the peculiar behavior of the fluids containing a structure such as polymeric fluids [9, 10], In 1993 J.R Lin et al. use the Brinkman-extended Darcy model within the porous medium to analyze the hydrodynamic lubrication of short porous journal bearings. The results show that the effects of viscous shear will increase the load capacity and decrease the coefficient of friction. Furthermore, the present analysis can correct and modify the previous study based on the Darcy model with slip-flow effects.[11] N.B. Naduvinamani et al. in 2001 theoretically investigate rheological effects of the couple stress fluids on the static and dynamic behavior of the pure squeeze films in the porous journal bearings. The present study predicts the effects of percolation of the polar additives (microstructures) into the porous matrix on the performance of squeeze films in the porous journal bearings. The most general modified Reynolds-type equation is derived for a porous journal bearing with no journal rotation. The analysis takes into account of the tangential velocity slip at the porous interface by using the BJ-slip condition. The cases of a short porous journal bearing under a constant applied load and that under an alternating load are analyzed. As compared to the Newtonian lubricants, the lubricants which sustain the couple stresses yield an increase in the load carrying capacity. [12], to get a better insight into the effect of surface roughness in porous bearings, Prakash and Tiwari (1982a) developed a stochastic model. The well-established stochastic theory of hydrodynamic lubrication of rough surfaces developed by Christensen and his coworkers (1970a, b) formed the basis of this work. In a series of papers (Prakash and Tiwari, 1982a, b, c), the model was applied to study the surface roughness effects for squeeze films between porous plates of various geometrical configurations. It was found that the presence of roughness asperities has a considerable influence on the bearing characteristics and the direction of influence depends not only on the roughness type but also on the nominal geometry and the operating parameters.[13,14,15], K. Gururajan et al. in 1998 Christensen's stochastic theory of hydrodynamic lubrication of rough surfaces is used to study the effect of surface roughness in an infinitely long porous journal bearing operating under steady conditions. It is shown that the surface roughness considerably influences the bearing performance; the direction of the influence depends on the roughness type.[16] later in 2000 the effect of surface roughness in hydrodynamic narrow porous journal bearings operating under steady conditions. The problem is formulated mathematically and solved analytically with appropriate boundary conditions. It is shown that the results are significantly different than those for the case of an infinitely long journal bearing. [17], N.B. Naduvinamani_, A. Siddangouda presents the theoretical study of the effect of surface roughness on the hydrodynamic lubrication of porous step-slider bearings. A more general form of surface roughness is mathematically modeled by a stochastic random variable with non-zero mean, variance and skewness. The generalized average Reynolds-type equation is derived for the rough porous step-slider bearing lubricated with Stokes couple stress fluid. The closed-form expressions for the mean load carrying capacity, frictional force and the coefficient of friction are obtained. The performance of the rough porous step-slider bearing is compared with a corresponding smooth porous step-slider bearing. The numerical computations of the results show that the negatively skewed surface roughness pattern increases the load carrying capacity and decreases the coefficient of friction whereas the adverse effects were found for the positively skewed surface roughness pattern. [18], Nitin et.al the present work, the hydrodynamic lubrication of a porous journal bearing is investigated with considering the effects of surface texturing at three different locations on the bearing surface operated with couple stress fluids. Darcy's equation is used to account for the effects of porous region of the bearing. The Stokes constitutive equations used for taking couple stress effects into account and the sinusoidal wave texture equation for texture at different locations on the bearing surface are used for deriving modified Reynolds equation. Centre differencing approach of finite difference scheme is adopted for discretisation of governing equations. It has been found that couple stress fluids improved the bearing performance. Moreover, the texture imposed on the bearing surface gives significant effects. Three configurations (configurations 1, 2 and 3) have been considered in the present work at three different locations and bearing performance characteristics have been calculated. The results revealed that the texturing improved the bearing performance in case of configuration 2 in comparison to two other locations (configurations 1 and 3). [19] Nitin et.al in a study of two non- Newtonian fluid models viz., power law fluid model and couple stress fluid model on the hydrodynamic lubrication of porous journal bearing has been investigated. In addition, sinusoidal type of surface texturing is incorporated at different configurations on the bearing surface to find the performance of the bearing in both cases. The modified Reynolds equation with Darcy model using Reynolds boundary conditions is solved by central differencing technique of finite difference method. The bearing performance characteristics are calculated numerically and are compared with each other. A direct comparison between the two models has been shown graphically. The power law index (n) has taken in the range 1.0 to 1.2 while couple stress parameter (l*) has taken in the range 0 to 0.6. Numerical results show that both models significantly improve the load carrying capacity (W) and reduce coefficient of friction (COF). The results are more effective for low eccentricity ratios instead of high eccentricity ratios. It has also been observed for surface texturing that configuration 3 (72° to 144°) gives optimum results for both load carrying capacity as well as COF, when compared with all other configurations. [20] The present study was conducted to examine the effect of laser surface texturing combined with couple stress fluids on the hydrodynamic lubrication of finite journal bearing in this work. The Jakobsson-Floberg-Olsson (JFO) boundary conditions were engaged instead of Reynolds boundary conditions to achieve realistic results. Moreover, the results were computed and authenticated with the previous published work. It was observed that the load-carrying capacity is increased with couple stresses for smooth journal bearings at different eccentricity ratios.

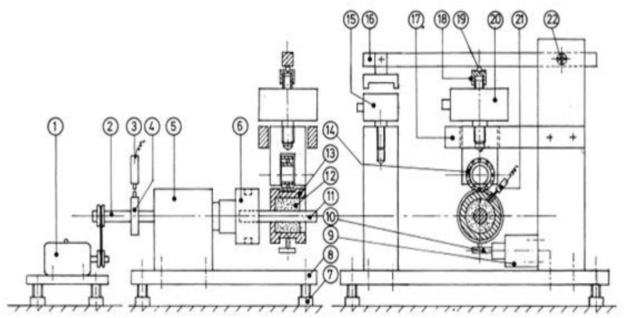

Fig.1 (Schematic diagram of the test rig for applying static and dynamic loads to journal bearing)

However, the increment in load-carrying capacity with texture affects only at low eccentricity ratios. The combined effects of texturing with couple stress fluids lower the performance of journal bearings at different eccentricity ratios. [21] R. Raman and T. S. Chennabasavan, in 1998 done the experimental investigations of porous bearings under dynamic loads. In this paper, the results of experimental investigation of porous bearings under vertical sinusoidally fluctuating loads were presented. The friction force was measured under various conditions of fluctuating load/steady load ratio, journal frequency and load frequency. The investigations were carried out in the hydrodynamic lubrication regime in a specially designed and fabricated test rig. It was found that at any given rpm, as the fluctuating specific load/steady specific load ratio, Pf/Ps, increases, the mean coefficient of friction mm increases. It was also found that the mean coefficient of friction is not affected by the load frequency even when the load frequency is half of the journal frequency. [22]

CONCLUSION

The progress on various aspects of hydrodynamic lubrication of porous journal bearings is reviewed, from recent research we find that, Non-Newtonian fluids replace the Newtonian completely numerical results show that non-Newtonian fluid models significantly improve the load carrying capacity (*W*) and reduce coefficient of friction (*COF*). The texturing is helpful to increase the load carrying capacity of the bearing but some particular type of the textures gave us use good results some researches provide us more interesting fact that rather than full textured surfaces partial textured surfaces provide more good results, in partial type of texturing cost and time both are saved It has also been observed for surface texturing that configuration gives optimum results for both load carrying capacity as well as *COF*, when compared with all other configurations.

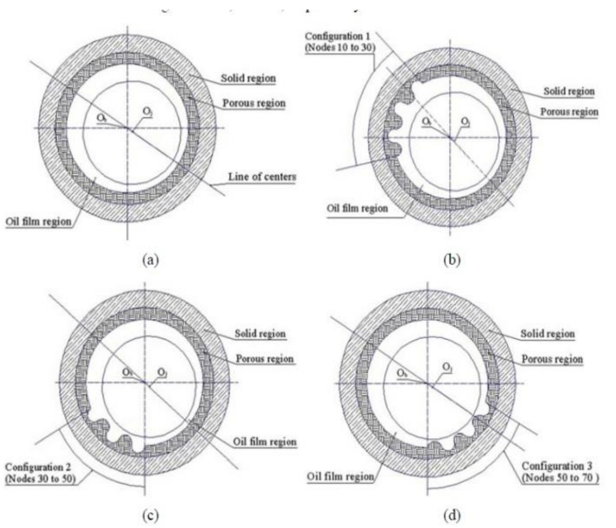

Fig.2 (Schematic representation of smooth porous journal bearing, (b), (c) and (d) surface texture at configurations 1, 2 and 3, respectively)

REFERENCES

[1] S. A. Tsukerman, Powder Metallurgy, Pergamon Press, Oxford, 1965.

[2] E. R. Booser, Plain bearing materials, Mach. Des., 42 (1970) 14 - 20.

[3] Margan VT, Cameron A. Mechanism of lubrication in porous metal bearings. In: Proceedings of the Conference on Lubrication and Wear, London. Institution of Mechanical Engineers, 1957:151–7.

[4] Cameron, V. T. Morgan in 1961 POROUS METAL BEARINGS consists of a bearing bush made of porous sintered metal. The pores of this matrix are impregnated with oil, which is some 30 per cent of the volume of the part, and this oil serves as a lubricant throughout the life of the bearing.

[5] Murti PRK. Hydrodynamic lubrication of short porous bearings. Wear 1972;19(1):17–25.

[6] Prakash J, Vij SK. Analysis of narrow porous journal bearing using Beaver–Joseph criterion of velocity slip. Tran ASME, JAppl Mech 1974;41:348–54.

[7] Gupta RS, Kapur VK. Centrifugal effects in hydrostatic porousthrust bearing. J Lub Tech 1979;101:381–5.

[8] Kaneko S, Hashimoto Y, Hiroki I. Analysis of oil-film pressure distribution in porous journal bearings under hydrodynamic lubrication conditions using an improved boundary condition. J Trib 1997;119:171–8.

[9] Ariman TT, Sylvester ND. Microcontinuum fluid mechanics—a review. Int J Eng Sci 1973;11:905–30.

[10] Ariman TT, Sylvester ND. Applications of microcontinuum fluid mechanics. Int J Eng Sci 1974;12:273–93.

[11] J. R. Lin, C. C. Hwang I Bearing lubrication by Brinkman-extended Darcy model.

[12] N.B. Naduvinamani et al. / Tribology International 34 (2001) 739–747.

[13] Prakash, J., and Tiwari, K., 1982a, "Lubrication of a Porous Bearing with Surface Corrugations," ASME JOURNAL OF LUBRICATION TECHNOLOOY, Vol. 104, pp. 127-134.

[14] Prakash, J., and Tiwari, K., 1982b, "An Analysis of the Squeeze Film between Porous Rectangular Plates including the Surface Roughness Effects," J. Mech. Engrg. Sci., Vol. 24, No. 1, pp. 45-49.

[15] Prakash, J., and Tiwaii, K., 1982c, "Effect of Supface Roughness on the Squeeze Film between Rotating Porous Annular Disks," J. Mech. Engrg. ScL Vol. 24, No. 3, pp. 155-161.

[16] K. Gururajan, J. Prakash, 1998," "Surface Roughness Effects in Infinitely Long Porous Journal Bearings," 146 / Vol. 121.

[17] K. Gururajan, J. Prakash, 2000, "the effect of surface roughness in hydrodynamic narrow porous journal bearings operating under steady conditions," Vol. 122 Õ 473.

[18] N.B. Naduvinamani, A. Siddangouda 2006,"Effect of surface roughness on the hydrodynamic lubrication of porous step-slider bearings with couple stress fluids," Tribology International 40 (2007) 780–793.

[19] Sharma, N., Kango, S., Sharma, R.K. and Sunil (2014) 'Investigations on the effects of surface texture on the performance of a porous journal bearing operating with couple stress fluids', Int. J. Surface Science and Engineering, Vol. 8, No. 4, pp.392–407.

[20] Sharma, N., Sharma, R.K, Sunil and Kango, S. 'A comparative study for lubrication of surface textured porous journal bearing with two different non-Newtonian fluid

models', Int. J. Surface Science and Engineering, Vol. X, No. Y, pp.000–000.

[21] Nitin Sharma, Saurabh Kango, Ashwani Tayal, Rajesh K. Sharma, and sunil, 2015, "Investigations on the Influence of Surface Texturing on a Couple Stress Fluid–Based Journal Bearing by Using JFO Boundary Conditions," TRIBOLOGY TRANSACTIONS http://dx.doi.org/10.1080/10402004.2015.1094840.

[22] R. Raman and T. S. Chennabasavan ,1998,"Experimental investigations of porous bearings," Tribology International Volume 31 Number 6 1998 325.