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Temperature profile of an elliptic bore journal bearing

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Abstract

Non-circularity in bearing bore is obvious due to manufacturing irregularities like eccentricity in tool and job axis, small-amplitude vibration during machining, etc. But design relations/charts in journal bearing are based on bore circularity concept. Hence in reality non-circularity in bearing bore is bound to occur. The non-circularity in this paper is assumed to be elliptical and the numerical solution of Reynolds equation and Energy equation has been carried out for an elliptic bore journal bearing to outline the temperature profile. A comparison is made with the circular case to analyse the effect of this irregularity. The energy equation is solved adiabatically.

Keywords: Elliptic bore; Journal bearing; Temperature profile; Film thickness; Pressure

1. Introduction

Reason and Narang [1] have presented a simple technique for the rapid design of steady-state journal bearing. This technique is amendable to hand calculator use. The results are compared with the numerical solutions for the relevant design parameters. Bearing designers can utilize this technique over a wide range of (L/D) ratio with great accuracy. Crosby [2] has investigated the performance of a journal bearing with a slightly irregular bore by assuming the bore to be elliptical and developed the governing equation in that case.

Jang and Chang [3] have presented the adiabatic solutions for a finite-width hydrodynamic journal bearing with non-Newtonian lubricant using power-law model. The oil film viscosity is taken as a function of temperature according to exponential law. The performance characteristics are obtained for various values of non-Newtonian power-law index. Barwell has developed an ampirical relation of temperature and pressure considering the thermal equilibrium of plain journal bearing [4,5]. Pinkus and Bupara [9] have carried out adiabatic solution for finite-width journal bearing.

Based upon the observation of above literature it has been realized that inclusion of bore irregularity in film thickness expression can be more realistic in predicting the various parameters of a journal bearing to better accuracy. It should not be confused here as elliptic bearing which is the lobe bearing made for the particular purpose. In this case ellipticity is a irregularity present in a bearing. Such bearing is the approximation of shape in form of an ellipse to consider mathematically the bore irregularity found in common circular bearing because of manufacturing inaccuracy and/or wear over a period of time of the bearing operation. This irregularity changes the load-carrying capacity by developing more than one reduced positive pressure zones, and hence a study to predict the performance due to non-circularity of the bore is essential and lead to this paper (circular bore being only a theoretical possibility). Fig. 1 below shows an elliptic bore bearing.

2. Isothermal pressure computation for elliptic bore bearing

Based on the geometry the non-dimensional film thickness is predicted by Crosby [2] for global orientation

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Nomenclature

A,B,E,F parameters substituted in energy equation
C radial clearance, mm
C_p lubricant specific heat, J/kg °C
d journal diameter, mm
e eccentricity
$e^p_{isothermal}$ error for convergency of isothermal pressure
$e^p_{thermal}$ error for convergency of thermal pressure
e^T error for convergency of temperature
G non-circularity coefficient $\left(= (R_{max} - R_{min})/c\right)$
h dimensional film thickness $(= Hc)$, mm
H non-dimensional film thickness $\left(= 1 + G\cos^2(\theta - \alpha) + \varepsilon\cos(\theta - \phi)\right)$
L bearing length, mm
N rpm
p dimensional pressure, N/mm^2
P non-dimensional pressure, $\frac{p\Psi^2}{\eta\omega}$
r_b bearing radius, mm
r_j journal radius, mm
R_{maj} major radius of bearing, mm
R_{min} minor radius of bearing, mm
T temperature at a point, °C
T_0 initial lubricant temperature, °C
$\bar{T}$ non-dimensional temperature $\left(= \beta_{thermal}(T - T_0)\right)$
T_{ratio} temperature ratio $\left(= (T - T_0)/T_0\right)$
U journal velocity, m/s
X coordinate in the direction of relative motion
z axial coordinate
Z non-dimensional axial coordinate $\left(= 2z/l\right)$

Greek letters

α inclination of major axis with load line, radian
$\alpha_{dissipation}$ dissipation number $\left(= (2\pi N)\eta_0\beta_{thermal}/\rho C_p (R/c)^2\right)$
ε eccentricity ratio
β length–diameter ratio $(= L/D)$
$\beta_{thermal}$ viscosity temperature index
δ ratio of R_{max} to R_{min}
η local viscosity, Pa S
η_0 reference viscosity, Pa S
$\bar{\eta}$ non-dimensional viscosity $\left(= \eta/\eta_0\right)$
ρ lubricant density, $\mathrm{kg/m^3}$
θ angular location of the film with respect to load line, rad
Ψ clearance ratio
ϕ attitude angle, rad
ξ ratio of bearing dimension
ω angular velocity, rad/s

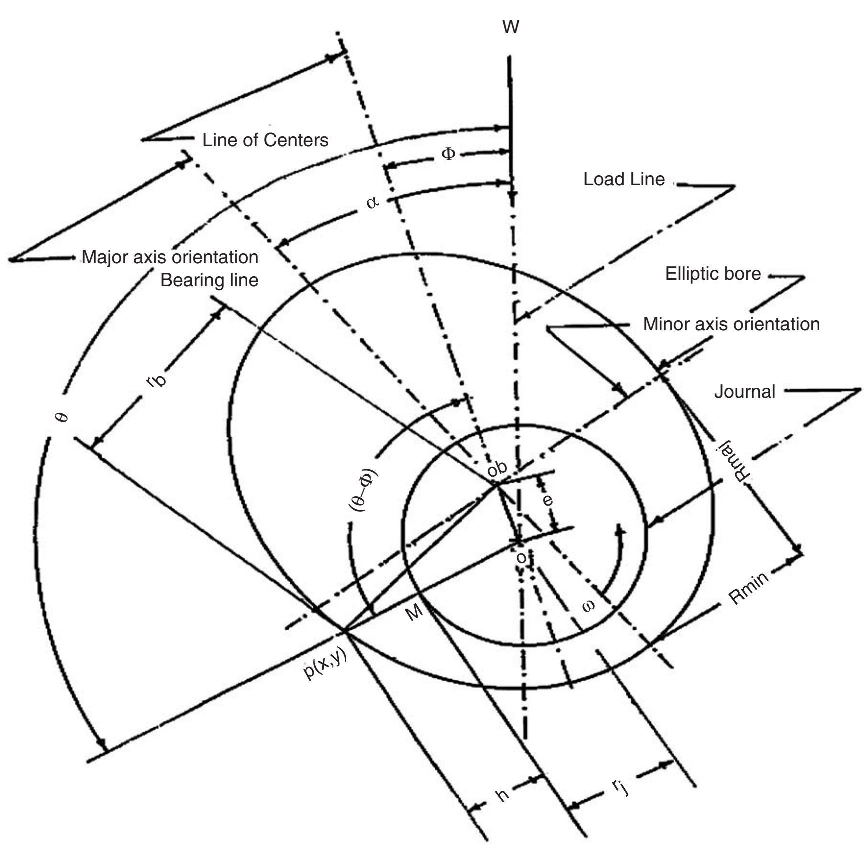

Fig. 1. Elliptic Bore Journal Bearing Schematic.