FORTRAN 9.0 USED FOR GENERATING CODES AND STUDY PRACTICAL MISALIGN SYSTEM

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Abstract - The bearing when loosely connected may influence bearing performance and its life. The paper describes a theoretical analysis for predicting bearing performance parameters of a loosely fitted hydrodynamic journal bearing system. Such bearing may cause misalignment either on a horizontal or vertical axis or on both axis of the bearing, depending upon the degree of severity of looseness. The study considers either slight tilt in the bearing axis on its axial (vertical) plane or twist on horizontal plane or twist on horizontal plane in terms of misalignment parameters τ and Δ respectively. The governing Reynolds equation is solved using finite element method (FEM) for the lubricant flow field in the clearance space of the journal bearing system by Galerkin's approach. The solution considers quadrilateral elements and the system equation is solved after applying a suitable boundary conditions. In the solution, the equilibrium conditions are established using iterative Newton-Rapson method. The paper discusses the effect of misalignment parameters on static performance parameters, which includes maximum pressure, minimum fluid film thickness, eccentricity ratio, attitude angle, frictional coefficient and fluid-film resisting moment caused due to misalignment for a specified range of speed. The result indicates a significant influence on static performance and therefore necessitates in depth further study.

Key words - FEM, hydrodynamic journal bearing, misalignment, Reynolds equation

I. INTRODUCTION

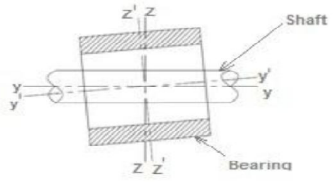


Fig. 1 Misaligned journal bearing

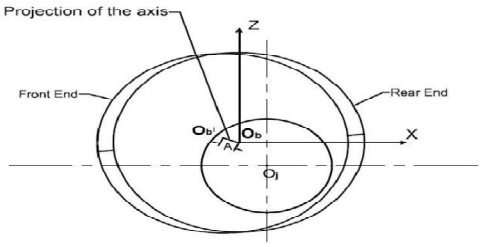


Fig. 2Co-ordinate system

Hydrodynamic journal bearings are commonly used for supporting rotating shafts subjected to high radial loads. The study concerning journal bearing assumes that journal and bearing are properly aligned, however in actual practice that may not be properly aligned due to improper/loosely fitting of the journal or bearing. As a consequence, the fluid film thickness profile in both circumferential and axial direction is modified resultinga change in bearing performance. The literature indicates a considerable study related to misalignment and its impact on bearing performance parameter. However no study has been undertaken for a loosely fitted bearing, which if allowed to operate may offset slide in axial (vertical) plane or twist in horizontal plane. The current study deals with the effect of loosely fitted bearing on the bearing performance parameter. The non dimensional fluid film thickness $\bar{h}$ considering the journal misalignment pressure is given as:

$$\bar{h} = 1 - \bar{X}i \cos\alpha - \bar{Z}i \sin\alpha + \Delta\beta\frac{Ri}{c}\cos\alpha - \tau\beta\frac{Ri}{c}\sin\alpha$$

Nomenclature	Non-Dimensional Parameters
c : Radial clearance x : circumferential coordinate y : axial coordinate Xj, Zj : journal center coordinate h : nominal fluid film thickness R j, Rb : radius of journal and bearing Δ : rotation about z-axes in counterclockwise direction τ: rotation about x-axis in counterclockwise direction μr : Viscosity of lubricant ω j : Rotational speed Wo : Load carrying capacity of the fluid film M : Resisting moment of the fluid film	$\bar{c} = c/Rj$, $\bar{F}o = Fo/(\mu r\ \omega j\ Rj^4/c^2)$ $\bar{P}max = Pmax/(\mu r\ \omega j\ Rj^2/c^2)$ $\bar{W}o = Wo/(\mu r\ \omega j\ Rj^4/c^2)$, $\bar{X}i = \frac{Xi}{Ri}$ $\bar{Z}i = \frac{Zi}{Ri}$, $\bar{h} = \frac{h}{c}$, $\beta = \frac{Y}{Ri}$, $\alpha = \frac{X}{Ri}$, $\bar{M} = M/\{\mu r\ \omega j Rj^3\ (Rj^2/c^2)\}$

In 1883 the celebrated Russian Nikilay Petroff concluded that friction in fluid-film bearings was a hydro dynamic phenomenon. McKee and McKee [1] were the first to record that, in the case of eccentric shaft loading, the maximum pressure location moves away from the axial center of the bearing in the same direction as the shaft in the point of application of load. Dubois, acvirk and wehe [2,4] conducted a detailed experimental analysis to determine the effect of misalignment on the performance of a journal bearing, particularly the pressure profile and the couple produced by the misalignment. After that Dubois [3] gives the misalignment properties for journal bearings. . Jang and chung [6] have obtained the adiabatic solution for the misaligned bearing considering the power law fluid model. Stokley and Donaldson [5] theoretically analyzed the effect of misalignment in a 180° partial bearing with misalignment caused by bending of the journal due to applied load.

The thin film thickness equation given by Guha [8] for a misaligned journal is modified to incorporate the effect of adjustments provided to the pad, but does not include pad distortion. Nikolakopoulos and Papadopoulos [7] presented an analysis of misaligned journal bearing operating in linear and nonlinear regions. The finite element method (FEM) was used to find the solution of the Reynolds equation. After the solution was obtained, they calculated the linear and nonlinear dynamic properties for the misaligned bearing depending on the developed forces and moments as functions of the displacements and misalignment angles.

The effects of misalignment on the linear and nonlinear plain journal bearing characteristics were analyzed and presented. A single pad externally adjustable fluid film bearing has been studied by Shenoy BS, Pai R [9] whereby the hydrodynamic conditions can be changed as required in a controlled manner. This paper investigates the combined effects of turbulence and couple stresses on the performance characteristics of a misaligned externally adjustable fluid film bearing.

The steady state form of Reynolds equation is solved numerically for a variety of simulated operating conditions. Also studied are the effects of different values of couple stress parameter, degree of misalignment and turbulence on the load capacity, the friction and side leakage.

B.S. Shenoy, R.Pai [10] studied the externally adjustable fluid-film journal bearing operating with negative adjustment configuration and lubricants with couple-stress, results in superior load carrying capacity with reduced friction and end leakage, as compared to a conventional partial arc bearing. However so far no investigation is available that addresses the analysis for predicting loosely fitted hydrodynamic journal bearing that affects the bearing performance.

II. RESULT AND DISSCUSION

A bearing when loosely fitted to a fixture become misaligned as shown in Fig. 1 and Fig. 2. In order to simulate the misaligned bearing model, a computer code is developed in fortran 90 using a salford compiler. Each module of the code is checked and verified for any bugs.

The bearing performance are computed for misalignment parameter Δ, τ = 0.0 and 0.0004. The simulated data have been plotted and shown in Figures 3 to 8.The fluid film thickness decreases with the misaligned parameter (Fig. 3)resulting an increase of maximum pressure as shown in Fig. 4.

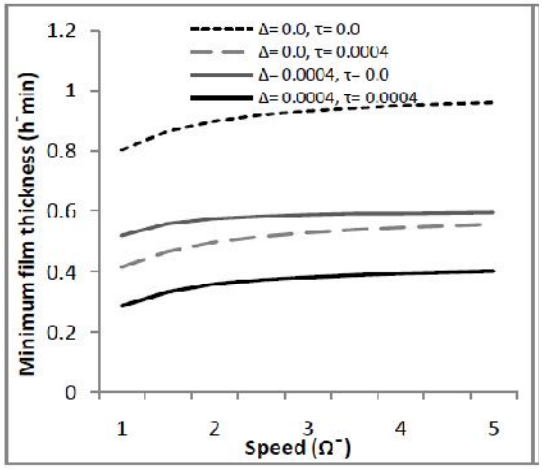


Fig. 3 Variation of minimum fluid film thickness as a function of speed

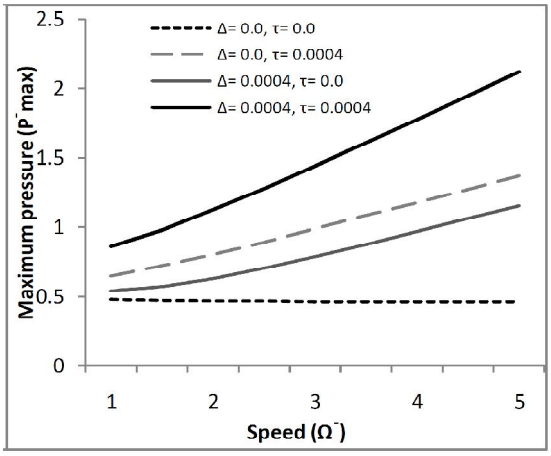


Fig.4 Variation of Max pressure as a function of speed

The film thickness reduction caused due to misalignment parameter also increases eccentricity ratio (ϵ) as shown in Fig. 5. Figure 6 represents the reduction of attitude angle (ϕ) with misaligned parameter indicating the degree of unstablity with the increase of speed.

The friction coefficient does not much influence with the misaligned parameter, however the lubricating film resulting moment has an impact on the misalignment parameter.

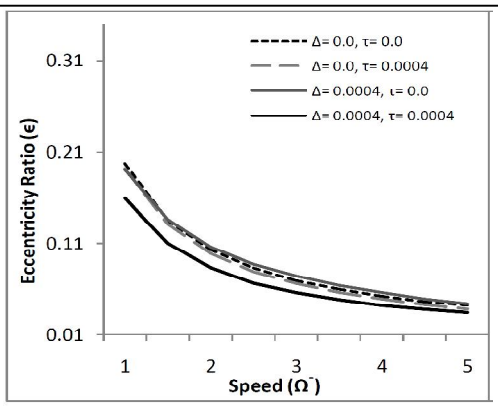


Fig. 5 Variation of Eccentricity as a function of speed

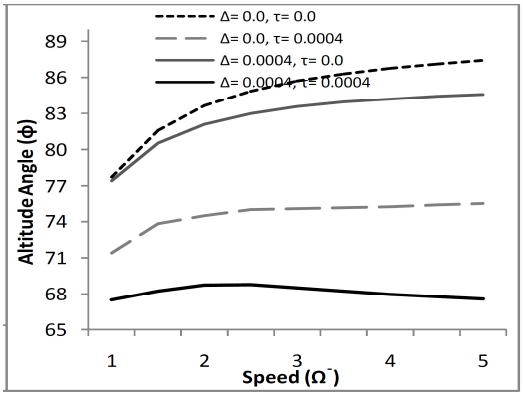


Fig. 6 Variation of Altitude angle as a function of load

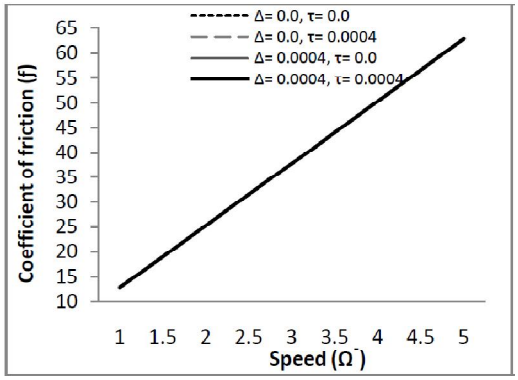


Fig. 7 Variation of Coefficient of friction as a function of speed

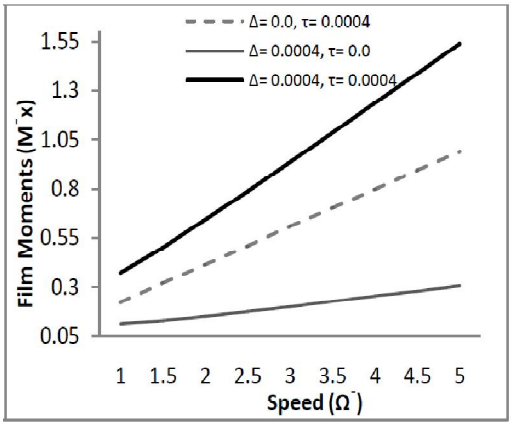


Fig. 8 Variation of moments M_x and as a function of speed

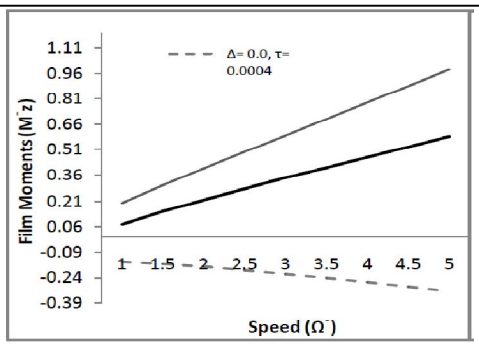


Fig. 9 Variation of moments $M_z$as a function of speed

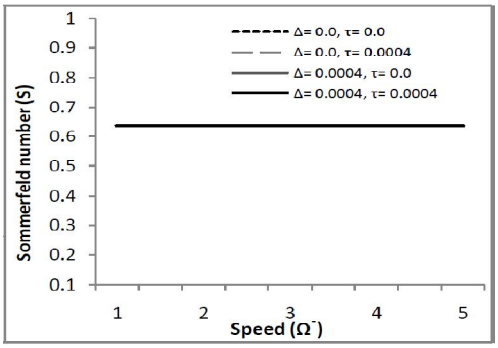


Fig. 10 Variation of Summerfield number as a function of speed

CONCLUSION

Based on the result it may be concluded that for a same degree of misalignment the horizontal twisting (Δ) misalignment parameter has a severe effect compared to vertical misalignment parameter.

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