EFFECT OF MISALIGNMENT ON THE STATIC CHARACTERISTICS OF 3-LOBE JOURNAL BEARING

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The operation of journal bearing in the conditions of misaligned axis of journal and bush leads to the load concentration on the bearing edges causing further mixed lubrication conditions, unstable operation and intensive wear of mating parts. For the design process of journal bearing the knowledge of static characteristics determined from the oil film pressure and temperature distribution is very important. For the 3-lobe journal bearing, the pressure, temperature and viscosity fields, load capacity, minimum oil film thickness, power loss, oil flow and maximum oil film temperature have been determined by iterative solution of the Reynolds', energy and viscosity equations.
The paper introduces the results of theoretical investigations of static characteristics of 3-lobe journal bearing operating at misaligned axis of journal and bush. An effect of misalignment ratio, length to diameter ratio of the journal bearing, the lobe clearance ratio on the static characteristics was investigated. Laminar, adiabatic model of oil film for the solution of Reynolds, energy and viscosity equations was applied.

Keywords: Multilobe journal bearings, Misalignment of axis

1. INTRODUCTION

The flexibility of rotor, as well as the errors of positioning or machining the bearings seats, causes the non-parallel orientation of journal and bearing axis. As result of axis misalignment [1,2] there are asymmetrical oil film pressure and temperature distributions in the axial cross-sections of the bearing. The misalignment of axis changes the static characteristics of bearing. As an example, the maximum oil film temperature can locally reach the extreme value damaging the oil properties and affecting at the same time the strength properties of bearing material having the low melting point.
The acquaintance of static characteristics for different geometric and operation parameters of 3-lobe bearing [1-5], operating at misaligned conditions, allows to choose the best design and operating parameters of the bearing. Because of wide application of 3-lobe journal bearings in high speed turbomachinery and still insufficient information on the effect of occurring misalignment, there is a necessity to give more data on this case of bearing operation.
For the 3-lobe journal bearing the oil film pressure, temperature and viscosity distributions have been received by iterative solution of the Reynolds', energy and viscosity equations [2,3]. The resulting force, attitude angle, minimum oil film thickness, load capacity, power loss, oil flow, maximum oil film pressure and temperature have been computed for misaligned operation of the bearing.

2. OIL FILM PRESSURE AND TEMPERATURE DISTRIBUTION

The geometry of the multilobe journal bearings (**Fig.1**) with misaligned axis [2,3] describes equation

$$H(\varphi,z)= H_c + \overline{H}(\varphi) + H_m(\varphi,z) \qquad (1)$$

The respective members of the right side of above equation are described by equation (1) through (4).

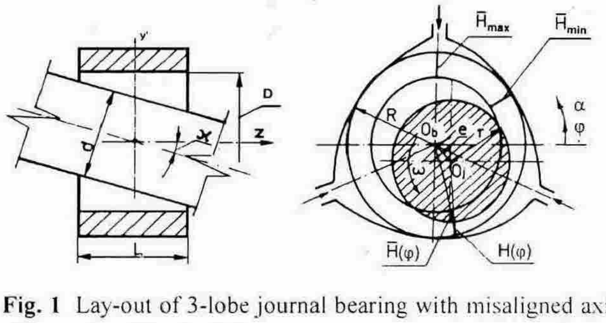

Fig. 1 Lay-out of 3-lobe journal bearing with misaligned axis of journal and bush; d, D ,r, R - journal and bush diameter and radius, $\overline{H}_{min}$, $\overline{H}_{max}$ - minimum and maximum oil film thickness, κ - angle of inclination.

$$H_c = 1-\varepsilon\cdot\cos(\varphi-\alpha) \qquad (2)$$

where: ε - eccentricity, φ - peripheral co-ordinate, α- attitude angle.

For the concentric position of the journal in the bush the geometry is described by equation. (3)

$$\overline{H}(\varphi) = 1 + 0.5 \cdot \psi_s \cdot \cos(\varphi - \gamma) \quad (3)$$

with ψ_s - segment clearance ratio ($\psi_s = \overline{H}_{max} / \overline{H}_{min}$). γ - peripheral co-ordinate of the segment centre.

Equation (4) gives the oil film gap for misaligned axis.

$$H_m = q \cdot z \cdot \cos(\varphi - \alpha) \quad (4)$$

where: q- inclination ratio and z - co-ordinate in the axial direction.

Oil film pressure, temperature and viscosity distributions in the oil film were defined on the basis of Reynolds, energy and viscosity equations [2,3].

$$\frac{\partial}{\partial\varphi}\left(\frac{H^3}{\eta}\frac{\partial p}{\partial\varphi}\right) + \frac{\partial}{\partial z}\left(\frac{H^3}{\eta}\frac{\partial p}{\partial z}\right) = 6\frac{\partial H}{\partial\varphi} + 12\frac{\partial H}{\partial\phi} \quad (5)$$

where: H - dimensionless oil film thickness, p - dimensionless oil film pressure, φ, z - peripheral and axial co-ordinates, $\phi = \omega t$ - dimensionless time, η - oil viscosity, ω - angular velocity.

The pressure boundary condition assumes the positive values only and the ambient pressure on the edges of the bearing.

3. RESULTS OF CALCULATION

The 3-lobe bearings with the aspect ratio L/D=0.5, L/D=0.8, the lobe relative clearance ψ_s = 3.0 and vertical load on the pad have been considered. Examples of results are given in **Fig. 2** and **Fig. 3**; at assumed bearing parameters an increase in misalignment coefficient q causes small changes in the values of maximum oil film temperature. The heat number was assumed as K_T = 0.1 ($K_T = \omega \cdot \eta_0 / c \cdot \rho \cdot \psi^2$ were: c - specific heat of lubricant (J/kg^{0}C), ρ - density of lubricant (kg/m^3, ψ - relative clearance (‰)

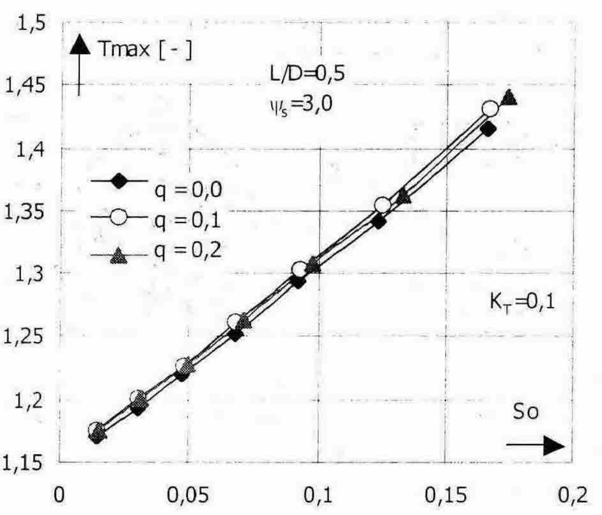

Fig. 2 Maximum oil film temperature for different values of misalignment coefficient

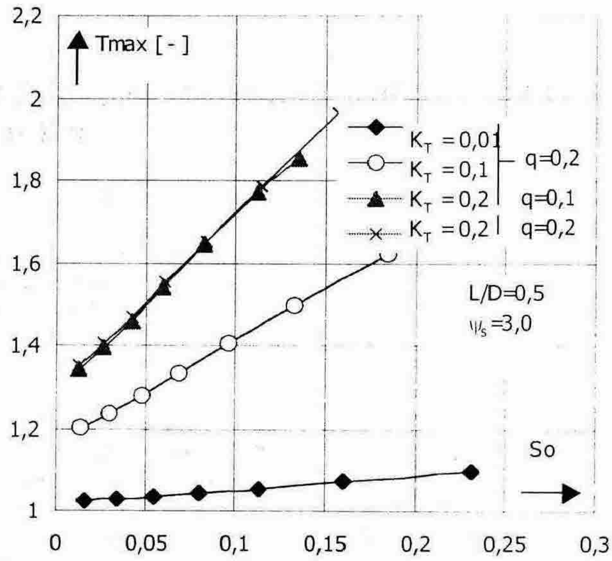

Fig. 3 Maximum oil film temperature for different values of heat number and misalignment coefficient

4. FINAL REMARKS

The results of calculation obtained for the 3-lobe journal bearing operating at misaligned axis of journal and bush in the static equilibrium position have stated that there is small effect of misalignment on the maximum oil film temperature at assumed bearing parameters. The calculated case relates to the assumed load direction.

5. REFERENCES

[1] Asanabe S., Akamoshi M.,Asai R., "Theoretical and experimental investigation on misaligned journal bearing performance". Inst. of Mech. Engrs., Tribology Convention. 1971.

[2] Huber M., Strzelecki S., Steinhilper W.: "Theoretical and Experimental Determination of the Performances of Misaligned and Statically Loaded Cylindrical Journal Bearings". Proceedings of the 5th International Tribology Conference in Australia. 6-9 December 1998. Brisbane. Australia. 243-248., 1998.

[3] Huber M., Strzelecki S., Steinhilper W., and Sauer B., "Theoretical and Experimental Determination of the Performances of Misaligned and Statically Loaded Cylindrical Journal Bearings". Transaction of Mechanical Engineering. Vol. ME24. No.1. 2000. The Institution of Engineers. Australia. pp. 31-37. 2000

[4] Strzelecki S.,"Extreme temperatures of three-lobe journal bearing operating with misaligned axis of journal and sleeve". Proc. of VIth Tribological Conference. 6-7 June 1996. Technical University of Budapest. .pp.34-39. 1996

[5] Strzelecki S. Litwicki W.,"Effect of misalignment on the reliable operation of turbomachinery journal bearing". Proc. of Vth International Conference on CONDITION&LIFE MANAGEMENT FOR POWER PLANTS. BALTICA V 2001. Helsinki-Stockholm-Helsinki June 6-8, 2001. Porvoo. Finland. pp.320- 33. 2001.