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OPERATION OF TILTING 5-PADS JOURNAL BEARING AT DIFFERENT GEOMETRIC PARAMETERS OF PADS

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Radial, tilting-pad journal bearings are applied in high speed rotating machines operating at stable small and mean loads and the peripheral speeds of journal reaching 150 m/s. The operation of bearing can be determined by static characteristics including the oil film pressure, temperature and viscosity distributions, minimum oil film thickness, load capacity, power loss, oil flow.
The operation of 5-lobe tilted-pad journal bearing has been introduced at the assumption of adiabatic oil film. The oil film pressure, temperature and viscosity distributions have been received by iterative solution of the Reynolds', energy and viscosity equations. The resulting oil film force, minimum oil film thickness, power loss, oil flow, maximum oil film pressure, maximum temperature were computed for different sets of bearing geometric parameters as: bearing length to diameter ratio, pad angular length and width as well as pad relative clearance.

Keywords: Tilting-pad journal bearings, Static characteristics

1. INTRODUCTION

Radial, tilting-pad journal bearings are applied in high speed rotating machines such as the steam and gas turbines, turbocompressors and turbine gearboxes operating at stable small and mean loads and the peripheral speeds of journal reaching 150 m/s. These bearings are hydrodynamically stable at high speed, less sensitive to load direction and shaft misalignment and they allow for minimising of oil flow and for using the standard components; spares consist of pads only. One of the advantages of tilting-pads bearings consist in progressive increase of the assembly stiffness with geometric preload [1-5]. If this is correct, the fractional frequency whirl can be completely suppressed. Some disadvantages of these type of bearings include a higher power loss and lower load capacity than other types of bearings, such as the elliptical and multilobe ones [4-7]. The number of tilting-pads can be basically 3 to 5 depending on the required operating parameters of rotating machine [1-4]. The operating surfaces of tilting-pads are the cylindrical ones with the pivot centered on the pad arc or displaced in the direction of journal rotation from the pad centre [3-5]. The length to diameter ratio of bearing is assumed from 0.5 to 1.0.
Solution of the basic equations of thermo-hydrodynamic theory of lubrication allows to receive the necessary data on the pressure, temperature distributions, the maximum value of pressure and temperature of oil film [6-8], the minimum oil film thickness, oil flow and friction forces, that means the static characteristics determining the input variables for the design of bearing.
The paper characterises the operation of the 5-lobe tilting-pad journal bearing with asymmetric support of pads. The Reynolds, energy, geometry and viscosity equations were solved numerically on the assumption of incompressible lubricant, the laminar and adiabatic flow of oil in the bearing gap of finite length bearing [2,3].

2. OIL FILM PRESSURE AND TEMPERARTURE DISTRIBUTIONS

The lay-out of tilting 5-pads journal bearing is introduced in **Fig. 1**. Each of pads of tilted-pad bearing aligns in static equilibrium position in such a position, that the resultant force of oil film goes through the support point of pad [1,2]. The geometric sum of resultant forces of single pad gives the reaction corresponding the external load. The resultant force of oil film acting on the pad consist of the pressure and tangential forces but

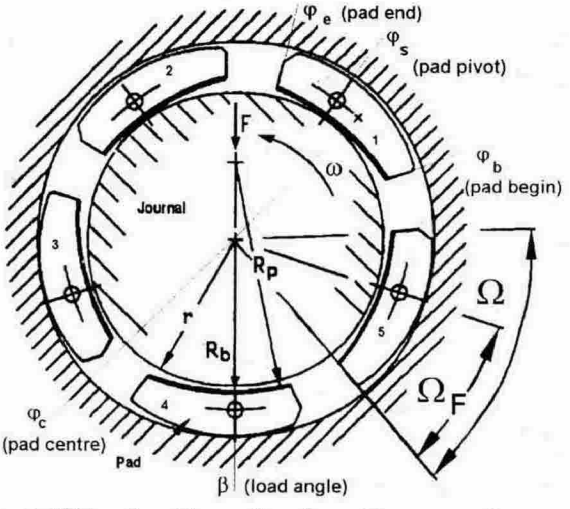

Fig. 1 Tilting 5-pad journal bearing with asymmetric support of pads

The oil film pressure, temperature and viscosity distributions of the oil film were determined on the basis of Reynolds, energy and viscosity equations [4,5]. The assumptions of fluid film lubrication, incompressible, Newtonian lubricant, no deformation of the pads [9] or the journal and parallel axis of journal and bearing, were made. The boundary conditions for the pressure and temperature include the value of inlet oil pressure and temperature [5]. Calculation of the temperature on the sides of bearing was determined by means of parabolic approximation [5-9].

3. RESULTS OF CALCULATION

An example of results for the tilting 5-pad journal bearings with length to diameter ratios L/D=0.5, different relative clearance ψ_S of the pads, asymmetrical support of the pad, i.e. pivot offset $\Omega_F/\Omega = 0.6$ is introduced in **Fig. 2** through **Fig. 4**. The pad inertia effects were neglected. The direction of the load F has been chosen as vertical one (load angle $\beta = 270^o$ – load on the pad: **Fig. 1**).

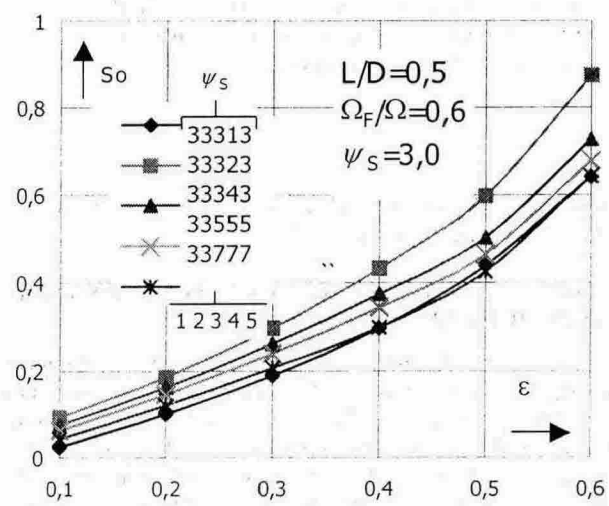

Fig. 2 Load capacity So for different relative clearance of pads (33313 means that for the pads No 1,2,3 - $\psi_S = 3$, pad No.4 - $\psi_S = 1$, and pad No. 5 - $\psi_S = 3$)

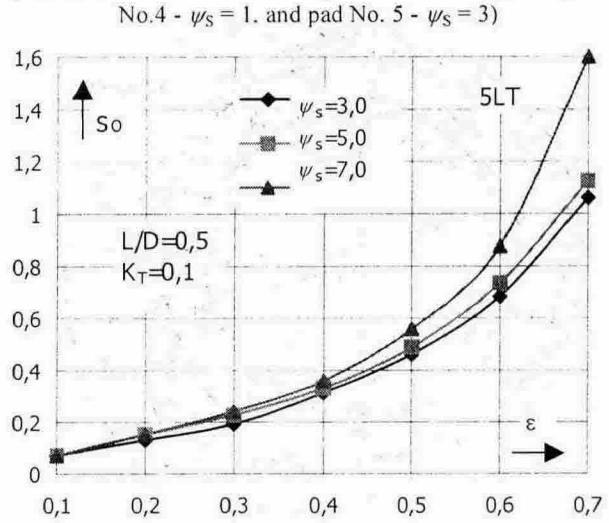

Fig. 3 Load capacity So for different relative clearance of pad

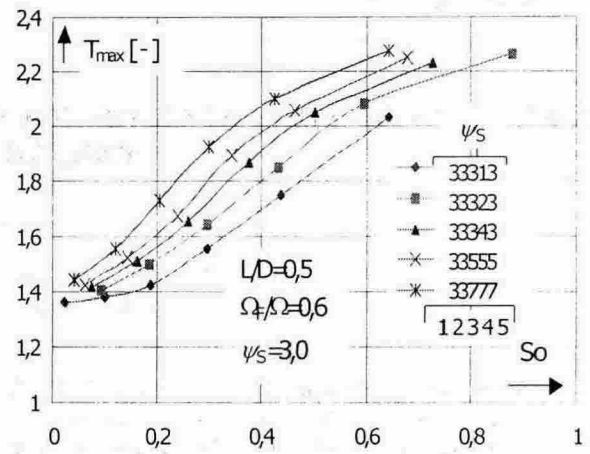

Fig. 4 Maximum oil film temperature T_{max} for different relative clearance of pads

4. CONCLUSIONS

The obtained results show that the operation of the 5-lobe tilting-pad journal bearing is effected by the geometric parameters of pads. Application of different pad relative clearance yields the variation of bearing static characteristics.

5. REFERENCES

[1] Lund, J.W., "Spring and Damping Coefficients for the Tilting Pad Journal Bearing", Trans. ASLE, 7. pp.342-352. 1964.

[2] Ott H.H., "Radiale Mehrflaechen-Gleitlager bei stationaerem Betrieb". VDI-Berichte Nr. 141. Duesseldorf. VDI-Verlag. pp.13-20.1970.

[3] Jones G.J., and Martin F.A., "Geometry Effects inTilting-Pad Journal Bearings". ASLE Transactions. Vol.22 No.3. 1979.

[4] Klumpp R., "Ein Beitrag zur Theorie von Kippsegmentlagern". Dissertation. Technische Universität Karlsruhe. 1975.

[5] Strzelecki S., "Load capacity of 5-lobe tilted-pad journal bearing". Proc. of 2000 AIMETA International Tribology Conference., L'Aquilla, Italy. pp.520-527. 2000

[6] Strzelecki S., "An Effect of Pad Support Position on the Dynamic Characteristics of Tilted 4-Pads Journal Bearing". ISCORMA-1. Proc. from the 1st International Symposium on Stability Control of Rotating Machinery. 20-24th August 2001, South Lake Tahoe, California, USA.Paper 3008.

[7] Strzelecki S., "An Effect of Pad Support Position on the Dynamic Characteristics of Tilting-Pad Journal Bearin". Synopses of 2nd World Tribology Congress. 6-7th September 2001. Vienna. Austria. p. 441. 2001

[8] Strzelecki S., Litwicki W., "Design and Calculation of Tilting-Pad Journal Bearings". Proceedings of Technical Scientific Conference on the Power Plant Problems. Belchatów 27-9 Sept 2001. p. 441-450. 2001.

[9] Strzelecki S., Kusmierz L., "Deflections of Pads in the Tilting-Pad Journal Bearing". Synopses of 2nd World Tribology Congress, 6-7th September 2001. Vienna. Austria. p. 438. 2001.