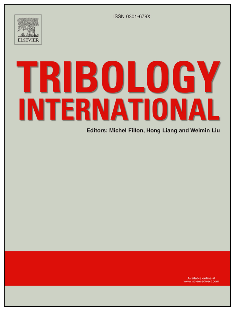
Accepted Manuscript



Theoretical and experimental study on the static and dynamic characteristics of tilting-pad thrust bearing

Weimin Wang, Binbin Liu, Ya Zhang, Xing Shao, Paul E. Allaire

PII: S0301-679X(18)30100-2

DOI: 10.1016/j.triboint.2018.02.019

Reference: JTRI 5118

To appear in: *Tribology International*

Received Date: 26 September 2017

Revised Date: 24 January 2018

Accepted Date: 19 February 2018

Please cite this article as: Wang W, Liu B, Zhang Y, Shao X, Allaire PE, Theoretical and experimental study on the static and dynamic characteristics of tilting-pad thrust bearing, *Tribology International* (2018), doi: 10.1016/j.triboint.2018.02.019.

Theoretical and experimental study on the static and dynamic characteristics of tilting-pad thrust bearing

Weimin Wang, Binbin Liu, Ya Zhang*, Xing Shao, Paul E Allaire[+]
Beijing Key Laboratory of Health Monitoring Control and Fault Self-recovery for High-end Machinery, Beijing University of Chemical Technology, Beijing, China
[+] Rotor Bearing Solutions International, Charlottesville, Virginia, USA

Abstract: The static and dynamic characteristics of tilting-pad thrust bearing (TPTB) considering the lubricant viscosity-temperature effect and pad elastic deformation are first analyzed by theoretical thermalelastohydrodynamic (TEHD) modeling. The TPTB test rig with electric oil pump is designed and built to apply axial loads and sinusoidal hydraulic excitation due to the opening changes in the overflow valve. An Instrumental Variable Filter (IVF) algorithm is developed to identify the TPTB stiffness and damping coefficients with pad pivot stiffness considered. Compared to the experimental results, the calculated TPTB temperature is more accurate after using the TEHD model. The TPTB stiffness and damping coefficients calculated by the pressure perturbation method are reasonably close to the experimental results with low-amplitude and low-frequency hydraulic excitation.

Keywords: Tilting-pad thrust bearing; TEHD model; Pad pivot stiffness; Sinusoidal hydraulic excitation

1 Introduction

The axial force of rotating machinery is composed of static force and dynamic force components. For turbine machines in power generation and refining petroleum, a balance disc is usually used to balance part of the static axial force, while the thrust bearing is used to bear the residual axial force. When excessive axial force occurs under machine working conditions and makes oil film stiffness on the thrust bearing surface exceed the standard, it will cause the bearing temperature to be too high, and may result in a pad fault due to overheating. The balancing force capability of the balancing device is relatively fixed, so the maximum dynamic forces generated in some operating conditions are mainly supported by the thrust bearing. The stiffness and damping coefficients of the thrust bearing are the main parameters that suppress the axial vibration of rotor. If the dynamic force is too large, the axial displacement will exceed the designed operating clearance and may lead to the damage of thrust bearing and the potential of a serious accident occurs. Therefore, with the increase of excitation force and rotation speed, the accurate prediction of static and dynamic characteristics of thrust bearings becomes more important. Meanwhile, the validation of the theoretical predictions by comparison to available experimental verification is essential.

Both theoretical and experimental research on the static characteristics of thrust bearing are very mature but stiffness and damping properties have not been as widely developed. Etsion[1, 2] , Huebner[3], Tieu[4], Kim [5], and Jeng[6-8] et al belong to the earlier scholars studying the steady state performance of thrust bearings, who contributed to build the theoretical model, and derived the solution of the Reynolds equation and the energy equation, but the researches were limited to the THD model and lack the relevant experiments. Dadouche and Fillon[9, 10] built a vertical thrust bearing test rig to compare and analyze the experimental data with the THD model simulation results of the fixed-pad thrust bearing, and the effect of oil supply temperature, bearing load and rotation speed on temperature field, oil film thickness and power loss were discussed. Glavatskih[11-13] completed the design and construction of a horizontal thrust bearing test rig with hydraulic loading to measure steady performance of thrust bearings. Later, Fillon and Glavatskih[14, 15] upgraded the THD model to a TEHD model, and investigated PTFE-faced centre pivot thrust pad bearings. Wodtke[16, 17] studied the influence of runner deformation and heat convection coefficient on results of TEHD analysis, and compared the predicted values with the measured data collected during a big hydro turbine thrust bearing operation.

Corresponding author at: Beijing University of Chemical Technology, 15 North Third Ring East Road, Chaoyang District 100029, China.
E-mail address: zhangya@mail.buct.edu.cn (Y. Zhang).