Evaluation of Operational Characteristics in a Large Thrust Bearing

Duriseti Venkata Srikanth, Department of Mechanical Engineering, Auroras' Engineering College, Hyderabad, India

ABSTRACT

In this paper the non dimensional load parameter, volumetric flow rate, energy flux, oil film temperature and power loss of a large thrust pad bearing are formulated. The objective of the paper is to determine the novel non dimensional thermal, volumetric and power loss parameters in addition to the known load and energy flux parameters of the bearing. The computation is done by formulating and numerically solving the oil film thickness, two dimensional Reynolds', Vogel-Cameron and energy equations at the different nodes of the pad oil film using a finite difference procedure. The lower the degree of the objective shape polynomial more is the accuracy of the slider bearing shape and pressure distribution. The developed derives the value of 'a' for which the load is maximum. The variation of the dominant bearing centre of pressure with respect to the corresponding values of 'a' is studied. From the equation of fluid film temperature the minimum rise in bearing temperature corresponding to the values of 'a' are determined. The oil film temperature distribution results are found satisfactory in terms of computer time and convergence criteria. The accuracy of the results is thoroughly validated by the variation of the load and thermal contours. This data and analysis serves as an input for rotor dynamic studies and includes the scope to develop safe operation of the bearing at high speeds in vertical hydro-electric rotors.

Keywords: *Convergence, Load, Non-Dimensional, Numerical Procedure, Parameter, Thermal*

1. INTRODUCTION

The present work encompasses the first stage of research activity aimed at understanding the phenomena involved in the working of a large thrust bearing tilting pad. The thrust segment enables change of the oil film geometry and maintains its optimum shape even with varied load. The principle of a thrust pad bearing is based on the convergent wedge which is formed between two relative moving surfaces.

To design thrust bearings, compatible with the given operating conditions, first the performance characteristics are determined. These are bearing load capacity, film thickness, stiffness, damping coefficients and film temperature as in Chu (2007). Formulation of the oil film shape for a flat sector-shaped bearing surface

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is done. Two dimensional Reynolds' equation is also formulated for this bearing. The energy equation governing the generation and transfer of heat is coupled and solved with the Reynolds' equation. The necessity and aim of this paper is to determine and verify the thermal and load parameters for a given range of film parameter and L/B ratios. Vohr (1981) made the first attempt to perform a rotor bearing analysis and include the comparison with experiments. His work was confined to a limited range of temperature measurements. It had certain inherent approximations although the agreement was quite good.

An understanding of the physics of the oil film and an improved calculation method are needed to predict performance and design of these bearings. Numerical solutions for the thermo elasto-hydrodynamic lubrication of a tilting pad based on the three-dimensional flow of a lubricant were obtained by Yang and Rodkiewicz (1997). A finite difference method was used to determine the pressure, temperature and elastic deformation of the oil film and pad respectively. For the performance of a large thrust bearing, Sinha, Athre and Biswas (2001) provided a realistic simulation of the Reynolds' equation when the film thickness was unknown and the centre of pressure was known together with the energy and the bending equations. Glavatskih, Fillon, and Larsson (2002) conducted an experimental and theoretical investigation into the effect of oil thermal properties on the functioning of a tilting pad thrust bearing. Poly-a-olefin oil, ester and mineral oil were chosen for the study. The theoretical and experimental data were compared and analyzed in terms of inlet and outlet film thickness, bearing operating temperature and power loss.

Kurban and Yildrim (2003) analyzed the hydrodynamic behavior of thrust bearings by using a proposed neural network predictor. Different dimensionless system pressures, speeds and geometries of the bearing were considered. The result gave superior performance for the behavior of a thrust bearing undergoing elastic deformation. Markin, Mc Carthy, and Glavatskih (2003) applied a finite-element method to analyze hydrodynamic tilting-pad thrust bearing performance. The model was first applied and the results compared well with those of experiments carried out on a spherically pivoted-pad. Ettles et al. (2003) compared results for two sizes of PTFE pads with corresponding Babbit bearings of nominally the same area. Theoretical predictions using GENMAT software were compared with test results. The effects of creep and power losses for the two types of bearings were found identical. Nicolleti and Ferreira (2004) studied the dynamic response of a rotor supported by a tilting pad bearing. An approach which included the hydraulic forces frequency distribution based on the equivalent oil film dynamic coefficients gave good results. Such vibration reduction in rotary machines increased the operational range. Mc Carthy et al. (2005) studied the influence of pad facing material in terms of oil film and pad temperatures and thicknesses. Two bearings one with white metal pad and the other with a layer of polytetrafluoroethylene (PTFE) based composite material were studied. The frictional torque, oil film and pad oil temperatures and thicknesses were monitored by mounting an array of sensors in the bearing and shaft. Oil film thicknesses in the two cases differed. However there was no significant difference in temperatures for the two bearings (Hemmi et al., 2005) computed the temperature distribution by solving the heat transfer in the oil, pad and interfaces simultaneously using a computational fluid dynamics package.

These results were used to compute the thermal and elastic deformation using an FEM code and determine the bearing characteristics. The comparison with experimental results validated the computational method. Zhao et al. (2005) developed a numerical procedure to analyse wavy thrust bearings assuming two circular rotating relative to each other. A Reynolds' equation based procedure simulated the wavy geometries and loading condition. Each of the nine linear stiffness and damping coefficients were calculated using a three degrees of freedom system. The eigen values of the system using these linear coefficients were