Effect of Contaminated Oil on Temperature Variation of Tilting Pad Thrust Bearing of Bronze Pads having Catenoidal Profile

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Abstract– *Tilting Pad Thrust bearings are generally designed to transfer high and axial loads from the rotating shaft. These bearings are widely used in rotating machines such as Turbines, Compressors, Pumps, etc. because of their low friction, good load bearing characteristics and high damping characteristics. The surface above the Pads has a significant impact over the bearings life. Thus, previous literature indicates that profiles have significant factors which influence the load carrying capacity of bearing. Therefore, the objective of this paper is to study the temperature variation of a Bronze material pad with Catenoidal surface over the over the pad. Thus, an experimental study has been performed which finds out the temperature results which provides a validation of theoretical models.*

Keywords- bearings life, catenoidal surface, damping characteristics, load bearing capacity, low friction.

1. INTRODUCTION

Tilting pad thrust bearings are designed to transfer high axial Axial (Thrust) Loads from rotating shafts with minimum power loss, while simplifying installation and maintenance. Here the Axial (Thrust) Load carrying surfaces are completely separated by an oil film, eliminating the risk of surface wear as long as a film of sufficient thickness is maintained. In order to attain hydrodynamic (full film) lubrication, the pad must sit at an angle to the oil flow so that a converging ''wedge'' is produced. Each bearing consists of a series of pads supported in a carrier ring; each pad is free to tilt so that it creates a self-sustaining hydrodynamic film. The carrier ring may be in one piece or in halves with various locations arrangements. They are used increasingly in marine drives, turbines, compressors and pumps. This flow constriction acts as a bottleneck, effectively slowing down the flow rate across the pad from the inlet edge toward the trailing edge. The gradually reducing available volume in the gap leads to a pressure build-up in the oil film giving rise to a force which "lifts" the shaft. Another contributory effect is the viscous flow resistance which prevents the oil from running out of the gap instantaneously as the pressure increases.

In the era of technological development, there is need of more analysis over the bearing pad surface, compact size of bearing which influences to high load carrying capacity and decreasing Power consumption.

This chapter discusses about the work or study done by writers, their objective and what conclusions they get from their study related to Tilting pad Thrust Bearing parameters.

A.P. Singh and C. Bagci [2] studied the effects of continuous circumferential surface profiles on the performance characteristics of a sector-type thrust bearing have been investigated. A computer-aided finite difference numerical solution of the Reynolds equation in polar form is determined with pressure distributions for an optimum inclination of a sector pad. These pressure distributions are then used to calculate the performance characteristics such as Axial (Thrust) Load-carrying capacity, flow rate, side leakage, friction power loss, coefficient of friction and temperature rise. The results for the non-dimensional performance coefficients which are defined as a function of the aspect ratio are then presented in the form of chart. A.J.Leopard [4] describes the development of a modified system of lubrication for tilting pad thrust bearing which results in considerable saving in power loss and also improvements in bearing safety factor. A. Dadouche et. al. [5] analysed the characteristics of a fixed-geometry thrust bearing in typical operating conditions and experimental results in order to validate future thermohydrodynamic models. The influence of the applied Axial (Thrust) Load, the rotational speed and the feeding temperature on the thrust bearing performance is presented and discussed. S.B. Glavatskih [6] presented paper, a method to improve temperature monitoring of fluid film bearings. The method is tested in an industrial tilting pad thrust bearing. Test results for steady state and transient operating conditions are reported. Temperature monitored by a thermocouple through the utilisation of the proposed method is compared to those measured by thermocouples in the pad backing and in the collar. The method is also tested on a PTFE-faced bearing. Test results showed that the proposed method improves sensitivity to thermal transients in conventional babbitted bearings and provides adequate means of temperature monitoring in the PTFE-faced bearings. S. Naduvinamani et.al [8] studied the combined effects of couple stresses and surface roughness on the performance characteristics with various film shapes such as cycloidal, plane, secant, hyperbolic and exponential. Dobrica and Filon [9] proposed a Thermohydrodynamic (THD) steady model and this model was applied

to well-known geometry of a slider pocket bearing. He found out that peak pressure developed in the pad transfer toward the trailing edge. Hargreaves [10] presented both theoretical as well as experimental results of surface waviness on pad bearings of rectangular slider pads. He found out that surface waviness on the bearing pad increases the Axial (Thrust) Load bearing capacity. Sharma and Pandey [11] compared the experimental results of pressure distribution with various single continuous surface profiles of pads such as cycloidal, catenoidal, polynomial and plane pads. He showed that the Cycloidal profile of pad generates about 30 % more pressure than the flat pad.

2. BEARING MATERIAL

Bearing life mainly depends upon the choice of bearing material, so it is important to select the bearing material correctly to service conditions and operating mode. The coefficient of friction of Bronze alloy lies between 0.08-0.14.

The Bronze bearing provides Low coefficient of friction, Good wear behaviour, High compressive strength, Structural uniformity and Corrosion resistance

3. DETAILS OF EXPERIMENTATION

3.1 Details of Test Rig

Table-1: Test Rig Detail

Sr. No.	Parameter	Parameter Value
1	Inside bearing diameter (D_1)	177 mm
2	Outside bearing diameter (D_2)	291 mm
3	Number of pads (n)	8 nos.
4	Mean diameter (D_m)	234 mm
5	Radial length of pad	57 mm
6	Circumferential width of pad (B)	57 mm
7	Lubrication type	Flooded
8	Viscosity of oil	At 40°C -94 centistokes At 100°C-14.3 centistokes
9	Density at room temperature	865 kg/m^3

3.2 Speed, Load and Cooling rate Variation

- Tilting pad thrust bearings are used in various engineering fields. They are widely used in 203 pumps. The speeds from this pump testing are selected.

- For Load variation, Hydraulic Jack is used. The load is varied by using a Direction Control Valve.

- The cooling rate affects the performance parameters of the system. A Flow control valve is used to vary the cooling rate from 0° to 90°. Depending upon the number of process parameters, L_8 Orthogonal Array is selected.

Table-2: Performance parameter

Level	Speed (rpm)	Load (kg)	Cooling Flow Rate (m3/sec)
1	981	1056	0.147
2	1152	3695	0.383

3.3 Instrumentation

The performance parameter to be measured is temperature. The sensors are specially selected and used to measure the respective readings. The methods for measuring the performance parameter are studied from previous literature surveys.

Temperature Measurement:

By studying previous literatures, Temperature Grid Method is selected. Guidelines given by Glavatskih [8] are used for selecting proper temperature sensor. A T-type thermocouple (copper-constantan) sensor is selected which measures in the range of -200°C to 350°C and sensitivity is about 43μV/°C. This sensor is fitted in a slot of 3mm depth.

Table-3: Temperature Locations

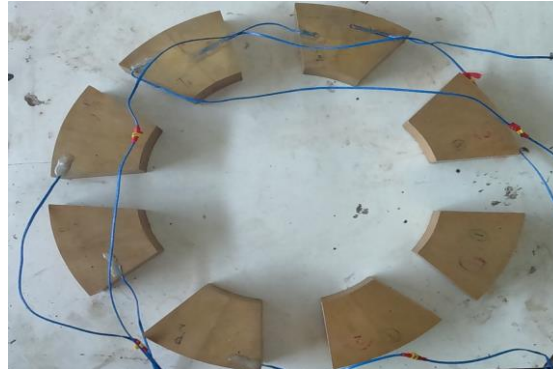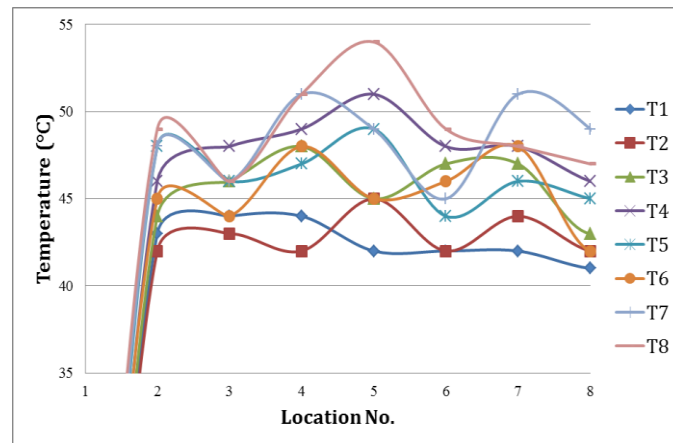| Temperature Nos.	Radial Position (in %)	Circumferential Position (in %)
T1	50	75
T2	85	75
T3	85	85
T4	75	85
T5	50	50
T6	50	85
T7	75	50
T8	Sump Temp.	

Figure 1 Arrangement of thermocouples over the pad

Figure 2 Contaminated Powder

4. RESULTS

The Graph shows respective temperature variations at different locations over pad.

Graph 1 Temperature variation on different locations

5. CONCLUSION

As One Gram of contaminated powder dust is added to lubricant, the Fluid temperature increases with increase in thrust load compared to Non contaminated oil. The experiment shows that the temperature shifts to trailing edge and the maximum temperature is observed towards the trailing edge of pad.

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