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Calculation of Equivalent Oil Film Temperature of Journal Bearing using ANSYS

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Abstract

The current work aims on calculating Equivalent oil film temperature of Hydrodynamic journal bearing using ANSYS software. The oil film temperature of Bush type journal bearing is calculated with the help of steady state thermal analysis. Oil film temperature is one of the very important parameter which affects the operation of bearing. As the oil film temperature increases , viscosity of oil decreases which reduce the load carrying capacity of bearing. Paper introduces one of the approach to find out the oil film temperature with the help of ANSYS. Analysis is done by taking L/D ratio 1, applied load 9KN and 3600 RPM for the operation of bearing. Then the result obtain by the ANSYS steady state thermal analysis is compared with numerical method.

Keywords: Hydrodynamic Journal Bearing , ANSYS, Steady State Thermal Analysis, Convection Heat Transfer Coefficient, Heat Generation Per Unit Volume

I. INTRODUCTION

Hydrodynamic Journal Bearing is used to support the rotating shaft extensively in high speed machinery, example turbines, electric motors etc. Circular bearing is the most commonly used profile of these bearings. These bearing support the external load and the presence of thick film of lubricant between the clearance spaces avoid the metal contact of rotating part of machinery with the surface of bearing. During operation of the bearing, due to high journal speed, the variation in temperature along the lubricant film significantly affects the properties of the lubricating oil. Hence it affects the performance of the bearing as the lubricating oil inside the bearing depends upon the pressure and the temperature. The increase in the temperature of the oil film causes the breakage in the layers of the lubricating film which consequently leads to metal contact between the bearing and journal surface. Here, the lubricant film between the journal and the bearing is responsible for low friction and high load carrying capacity of such bearings. The variation in temperature and pressure of lubricant in journal bearings affects the performance of the bearing. In order to investigate the influence of oil supply conditions on the performance of a journal bearing. The supply conditions considered were oil supply temperature, supply pressure, groove length and groove location. To carry out this study, the hydrodynamic pressure distribution inside the bearing has been determined using a mass-conserving cavitation model with realistic supply conditions. The energy equation and the heat conduction equation have been used for the determination of oil film and bush temperature distributions [1]. At low eccentricity tests the maximum temperature occurred at the unloaded lobe of the bearing, with the downstream groove contributing poorly to bearing cooling. As eccentricity increased, a temperature increase in the loaded lobe of the bearing was observed, along with a temperature decrease in the unloaded lobe. At high eccentricities the downstream groove was found to contribute significantly to bearing cooling. Shaft temperature and oil outlet temperature did not seem to be significantly affected by increasing load [2]. From parametric study it is found that the temperature of the fluid film raises due to frictional heat thereby viscosity, load capacity decreases. Increased shaft speed resulted in increased load carrying capacity, bush temperature, flow rate and friction variable [3]. The bearing has obvious effect on the temperature of lubricating oil film, maximal film pressure, leakage flow rate of ends and misalignment moment. The surface roughness and viscosity - pressure effect of lubricant have a great influence on the lubrication performance of misaligned journal bearing with larger eccentric ratio [4]. The temperature influence on the journal bearings performance is important in some operating cases, and that a progressive reduction in the pressure distribution, in the load capacity and attitude angle is a consequence of the increasing permeability. The Reynolds equation of thin viscous films was used taking into account the oil leakage into the porous matrix, by applying Darcy’s law to determine the fluid flow in the porous media [5]. To analyze the pressure distribution in hydrodynamic journal bearing for various loading conditions and various operating parameters. The space between the shaft and the bearing is called lubrication gap and is filled with lubricant. Journal bearing test rig is used to test the 140 mm diameter and 70 mm long bearing. Test bearing is located between two antifriction bearings. The bearing was loaded mechanically [6]. An experimental work was conducted to determine the temperature distribution around the circumference of a journal bearing. A journal diameter of 100mm with a ½ length-to-diameter ratio was used. Temperature results for different radial loads and speeds were obtained [7].The evolution of temperature with time in a deep-groove ball bearing in an oil-bath lubrication system is studied both experimentally and analytically. The test apparatus is a radially-loaded ball bearing instrumented to measure the frictional torque as well as the transient temperature of the outer race, oil and housing. Simulations results indicate that higher rotational speed, oil viscosity and housing cooling rate lead to the larger temperature gradient and thermally-induced preload in ball bearings [8].

II. NUMERICAL METHOD

The following parameters are taken for the solution of a journal bearing using Numerical method:

Table - 1
Parameter Involved In Modelling

Length of the bearing (L)	*80 mm*
Radius of Shaft (R_s)	*80 mm*
Radial Clearance (C)	*0.06mm*
L/D Ratio	*1*
Eccentricity ratio(ε)	*0.44*
RPM	*3600*
Lubricant density (ρ)	*840 Kg/m3*
Load	*9 KN*

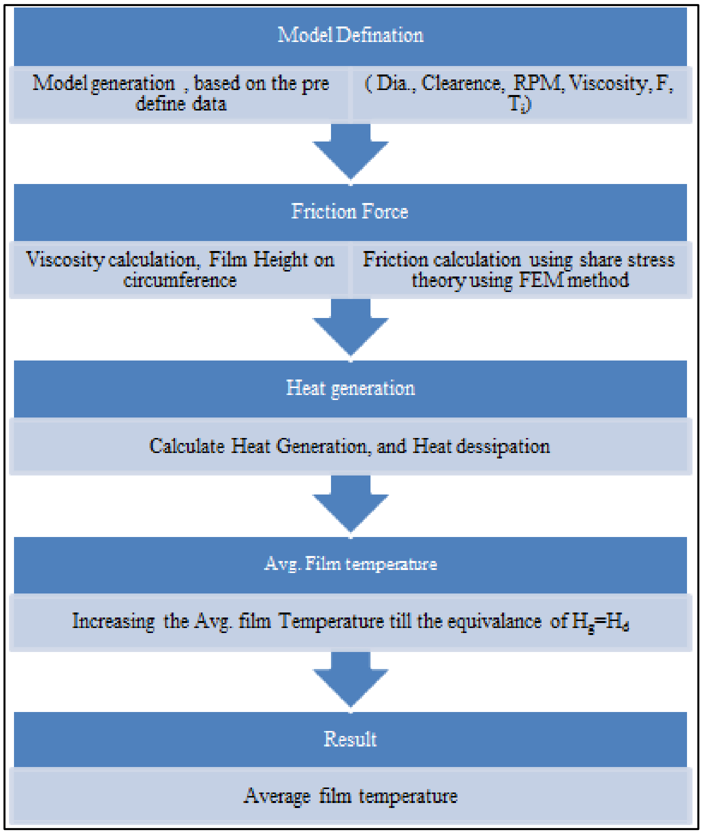

Fig. 1: Algorithms Adopted For Calculating Average Oil Film Temperature

III. ANSYS STEADY STATE THERMAL ANALYSIS

The Ansys/ Multiphysics, Ansys / Mechanical, Ansys/ FLOTRAN, and Ansys/ Thermal product support steady state thermal analysis. A steady state thermal analysis calculates the effects of steady thermal loads on a system or component. Engineer often perform a steady state analysis before doing a transient thermal analysis to help establish initial condition. In steady state thermal analysis is used to determine temperature, thermal gradient, heat flow rates and heat fluxes in an object that are caused by thermal loads do not vary over time such loads includes the following:

1) Convections
2) Radiation
3) Heat Flow Rates
4) Heat Fluxes (heat flow per unit area)
5) Heat generation rates(heat flow per unit volume)

6) Constant temperature boundaries

A Steady state thermal analysis may be either linear with constant material properties or non- linear with material properties that depend on temperature. The thermal properties of most material do vary with temperature so the analysis usually is nonlinear including radiation effects also makes the analysis non linear.[9]

Working principal of ANSYS: There are three following steps by which a problem can solve in ANSYS

1) Preprocessing
2) Solution
3) Post processing

Preprocessing contains selection of element, model generation of element and meshing of element. In FE Modelling pre-processing involves the cleaning of the geometry as per the FE interface. The model is meshed into No. of elements to reduce the degree of freedom using inbuilt meshing modeler. In present study the model comprises of three important parts for meshing
Write about the modeling

1) Journal (Shaft) surface
2) Bearing Internal surface
3) Lubrication Film. i.e.
   – Front seal
   – Mid-plane cross section film

Solution contains applying boundary condition on the element . The boundary conditions also play important role in setting appropriate model. The Boundary conditions applied are presented in table no. (3.2). Journal surface is considered as a “Moving wall”, with an angular velocity (ω) of 94.2 and has a rotation co-ordinate same as the co-ordinate of center of Bearing in CAD Model that is (0mm,-0.105mm). Bearing surface is considered to be “Stationary wall”. Symmetry is taken about the mid cross sectional plane of journal bearing and front oil film is considered as a pressure re Outlet set to zero atmospheric pressure at initial condition. Post processing gives the result of given problem. [9]

A. Model Generation:

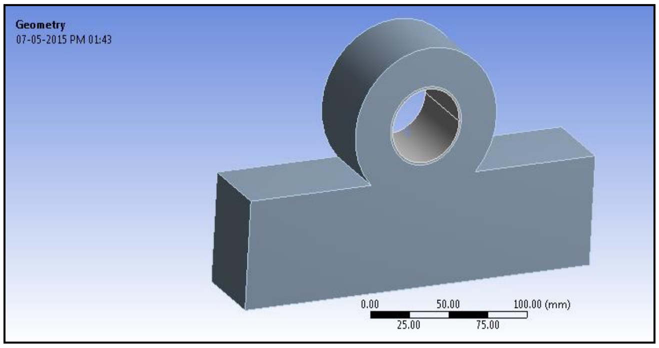

Fig. 2: Model Generation of Bush Type Journal Bearing

B. Meshing Generation with Hexagonal Element:

Meshing size is 4 mm, No of elements 20875

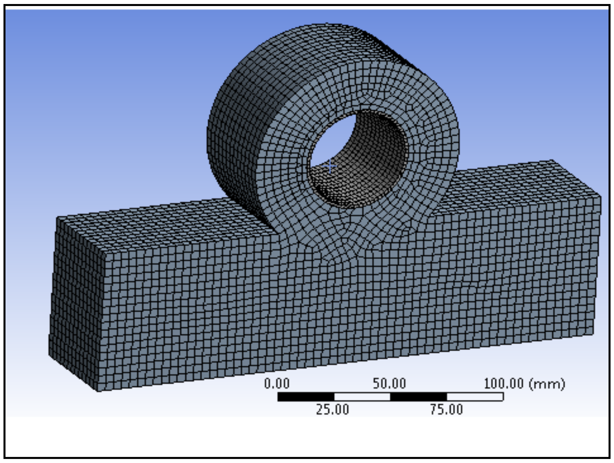

Fig. 3: Hexagonal Element Meshing of Model in ANSYS

C. Boundary Conditions:

For the calculation of oil film temperature principal of convection is applied on the given element. Calculated value of Heat generation per unit volume (w/mm^3) and convection heat transfer coefficient (w/mm^2 ^{0}c) are given as a boundary condition:
Internal heat generation= 2.35* 10^{-3} W/mm^3
Convection heat transfer coefficient= 9* 10^{-6} w/mm^2 ^{o}c , for the moving air at 2.5 m/s at 30^{o}c

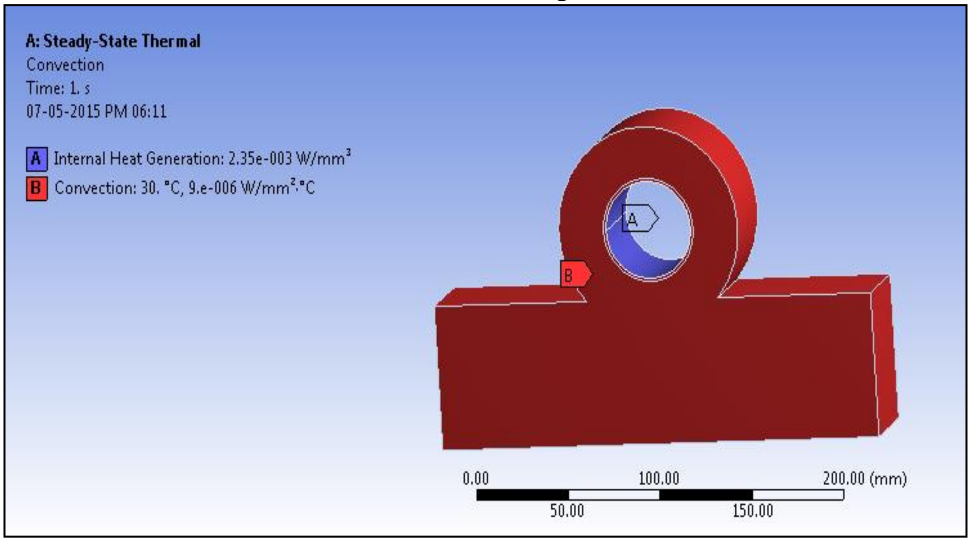

Fig. 4: Applying Boundary Conditions on the Element in ANSYS

IV. RESULTS

Appling algorithm on the parameters given in table we get the numerical modelling solution using MATLAB,
Heat generation= 19.6W
Heat dissipation= 20W
Average Film temperature= 62 ^{O}c
Result obtain by post processing in ANSYS steady state thermal analysis:

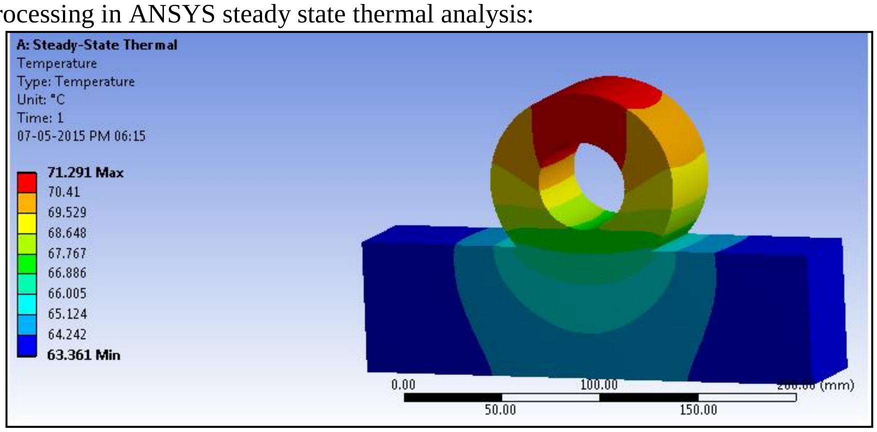

Fig. 5: Temperature variation across the bearing using ANSYS

V. CONCLUSION

Equivalent oil film temperature of journal bearing has been calculated by two different approaches one is ANSYS software and other is numerical method using MATLAB software. The temperature comes out from the numerical method is 62oc , this is the average oil film temperature of bearing at the steady state condition when the Heat generation is equal to the Heat dissipation. When using ANSYS software by doing steady state thermal analysis we get the temperature variation across the bearing. The highest temperature comes out for the given condition for bearing is 71.2oc. The % deviation between two method is approximately 12% which is in acceptable limit. ANSYS gives the more exact result as compare to the numerical method , we can get the temperature across the whole bearing with clear coloured visual. ANSYS steady state thermal analysis may become a alternative method for the calculation of oil film temperature over the analytical method and numerical method.

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