Pressure Distribution in Hydrodynamic Journal Bearing using CFD

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Abstract- *The advanced machines are pivoting at rapid and convey high rotorloads in industry. For such applications, Hydrodynamic diary bearing is required.Journal Bearings are utilized to help shafts and to carryradial loads with least power misfortune and least wear. Here weobtain weight appropriation in the ointment stream by disregarding the weight variety over the film thickness in diary bearing.Three dimensional study has been improved the situation weight conveyance within the domain. We find out the variation in Pressure with change in eccentricity as well as change in angular speed.*

Introduction

The example to achieve quick with higher execution of the bearing is extending in present day organizations. Starting late, PC development has extended to a more conspicuous degree, various scientists and experts began to use business computational fluid components (CFD) programs in their investigation. The full Navier– Stokes conditions are used in CFD coding and gives a response for the stream issue, while restricted difference codes rely upon the Reynolds condition. The results gotten by the two frameworks are not definitely same. Furthermore, the CFD groups are used in 3 dimensional and complex geometries because constrained difference procedure ends up being greatly mistaken for these geometries.

2. Theoretical background

1. Here the summed up Reynolds condition will be gotten from the Navier-stirs conditions and the progression condition with couple of suppositions.
2. Body forces are neglected.
3. The weight is consistent through the film thickness. As the film is just a single or two 1000th of an inch thick it is in every case genuine.
4. The surfaces ebb and flow is huge contrasted and movie thickness surface speeds require not be considered as differing in bearing.
5. The oil is Newtonian.
6. Stream is laminar.
7. Fluid inertia is neglected
8. The viscosity is constant throughfilm thickness. This is surely not true but leads the great complexity (if not assumed)

Newton's viscosity relation which states

$$\tau = \eta \frac{\partial u}{\partial z}$$

So $\frac{\partial p}{\partial x} = \frac{\partial}{\partial z}\left(\eta \frac{\partial u}{\partial z}\right) \ldots \ldots . . (1)$

In the y direction, a similar equation follows:
$\left(\frac{\partial \tau}{\partial z}\right)_y = \frac{\partial p}{\partial y}$ and here $\tau_y = \eta \frac{\partial v}{\partial z}$
So $\frac{\partial p}{\partial y} = \frac{\partial}{\partial z}\left(\eta \frac{\partial v}{\partial z}\right) \ldots\ldots\ldots(2)$

Also $\frac{\partial p}{\partial z} = 0$
The boundary conditions are simple as the speed of the fluid at the surface is the speed of the surface itself (assumption 4),
So on $z = h, u = U_1$
And on $z = 0, u = U_2$
Where U_1, U_2 are the two surface speeds.
Substituting these into (4) produces
$\eta U_2 = C_2$ and $\frac{\eta(U_1 - U_2)}{h} - \frac{\partial p}{\partial x}\frac{h}{2} = C_1$
Hence from (4) the velocity u in the x direction at any point z in the film is:

$$u = \frac{1}{2\eta}\frac{\partial p}{\partial x}(z^2 - zh) + (U_1 - U_2)\frac{Z}{h} + U_2 \ldots\ldots \quad (5)$$

Where ∂p/∂x is the pressure gradient, η the viscosity, U_1 and U_2 surface speed on $z = h$and$z = 0$; and of course from (5) the velocity gradient is
$\frac{\partial u}{\partial z} = \frac{1}{\eta}\frac{\partial p}{\partial x}\left(z - \frac{h}{2}\right) + \frac{(U_1 - U_2)}{h} \ldots\ldots (6)$
Now the integral $\int_0^h u dz$ equals $q_x$the flow rate in the x direction per unit width of y. This is easily achieved as (5) can be integrated directly.

$$q_x = \left|\frac{1}{2\eta}\frac{\partial p}{\partial x}\left(\frac{Z^3}{3} - \frac{Z^2 h}{2}\right) + (U_1 - U_2)\frac{Z^2}{2h} + U_2 z\right|_0^h$$

Putting in limits and simplifying:

$$q_x = -\frac{h^3}{12\eta}\frac{\partial p}{\partial x} + (U_1 + U_2)\frac{h}{2} \ldots\ldots (7)$$

If the same procedure is followed for y it is easily found that
$$q_y = -\frac{h^3}{12\eta}\frac{\partial p}{\partial y} + (V_1 + V_2)\frac{h}{2} \ldots\ldots\ldots (8)$$
Where V_1 and V_2 correspond to $U_1$and U_2

Full Reynold equation

It is now possible to rewrite the q_x and q_y in the continuity equation.
$\frac{\partial q_x}{\partial x} + \frac{\partial q_y}{\partial y} + (w_h - w_0) = 0$
Replacing them by equations (7) and (5) gives
$\frac{\partial}{\partial x}\left\{(U_1 + U_2)\frac{h}{2} - \frac{h^3}{12\eta}\frac{\partial p}{\partial x}\right\} + \frac{\partial}{\partial y}\left\{(V_1 + V_2)\frac{h}{2} - \frac{h^3}{12\eta}\frac{\partial p}{\partial y}\right\} + (w_h - w_0) = 0$
This can be arranged as

$$\frac{\partial}{\partial x}\left(\frac{h^3}{\eta}\frac{\partial p}{\partial x}\right) + \frac{\partial}{\partial y}\left(\frac{h^3}{\eta}\frac{\partial p}{\partial y}\right) = 6\left\{\frac{\partial}{\partial x}(U_1 + U_2)h + \frac{\partial}{\partial y}(V_1 + V_2)h + 2(w_h - w_0)\right\} \ldots (9)$$

This is Reynold equation in 3D with everything varying.

3. Literature survey

A diary bearing is one of the machine segments with the longest history of logical investigation of some other class of liquid course. Diary heading are machine segments which are usually used to convey spiral loads in both dry and greased up conditions. A stacked, turning shaft (diary) is upheld in a roundabout hedge (bearing) with a marginally bigger width than the diary. CFD work began in the late 1970s with the use of the control volume method.The potential utilization of Computational Fluid Dynamics (CFD) for taking care of unfaltering state hydrodynamic grease issues for diary bearing was analyzed by Chen and Hahn (1998). They discovered that the CFD technique is precise for unraveling enduring state problems.Cabrera et al; (2005) estimated the liquid film weight on water greased up elastic diary bearing. It was affirmed from CFD that perplexing film weight circulation exists over the stacked parts of the bearing. The appropriation is the consequence of the cooperation of the flexible bearing surface redirections with the movie weight. Zenglin.G Toshio.H andGordon. K.R. (2005) introduced the correlation between the present PC projects and CFD examination utilized in industry has been made. The CFD technique has been connected to grease stream inside cushion orientation having expansive shut pockets or recesses.Ranjan et al. (2006) exhibited a CFD approach, utilizing FLUENT, to show liquid stream in a diary holding on for three similarly dispersed hub grooves which was provided with water from one end. K. P. Gertzos, P. G. Nikolakopoulos and C. A. Papadopoulos chipped away at CFD examination of diary bearing hydrodynamic oil by Bingham lubricant. They fathomed Navier–Stokes conditions utilizing the FLUENT and the outcomes are thought about of the created 3-D CFD display with past examinations, for both Newtonian and Bingham greases, and discovered great agreement. Jourak et al. (2008) examined the impact of one dimple on rotor (shaft) and Full Navier-Stokes conditions are illuminated under insecure conditions by the creators with the business programming ANSYS CFX 11.D.M. Nuruzzaman et al. examined the Pressure Distribution and Load Capacity of a diary Bearing Using Finite Element Method and Analytical Method. They think about the results. Ravindra R. Navthar et al. (2010) explored soundness of a Journal Bearing themohydrodynamically.

4. Journal bearing modelling

Table 1:Input data for bearing analysis

Radius of shaft ($R_{s)}$	50 mm
Radius of Bearing ($R_{b)}$	50.5 mm
Clearance (C)	500 μm
Lubricant Density (ρ)	840 kg/m3
Viscosity of Lubricant (η)	0.0127 Pas

To proceed in this analysis, first a 3-dimensional bearing has been generated in ANSYS FLUENT 13.Figures below show the 3D-and meshed geometry in ANSYS WORKBENCH.

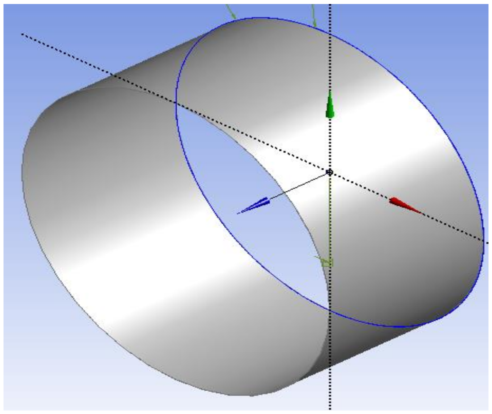

Fig1: 3D representation of a smooth journal bearing in ANSYS

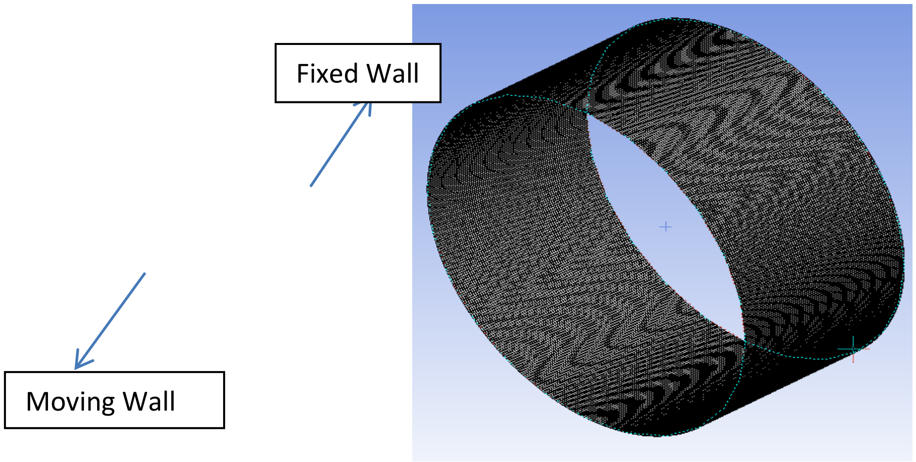

Fig2: Grid of Journal Bearing

5. Result and discussion

The L/D ratio is 0.6 and different values of angular velocity are taken for pressure variation at different eccentricities and differ angular velocities are analysed.Steady Conditions are selected for the analysis.

Pressure Distribution

Pressure distribution in the journal Bearing by ANSYS FLUENT

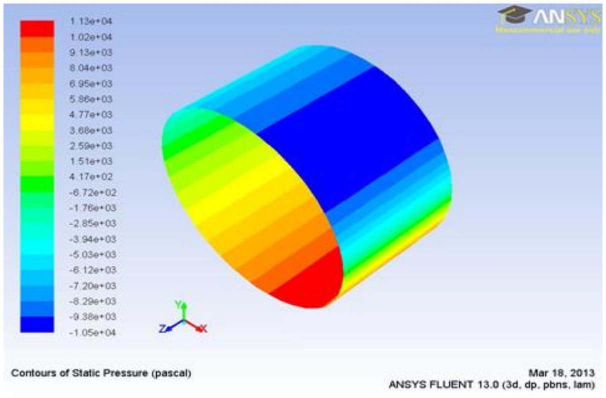

Fig 3: Pressure Contour forL/D =0.6 at e=0.2 and N=1000 rpm

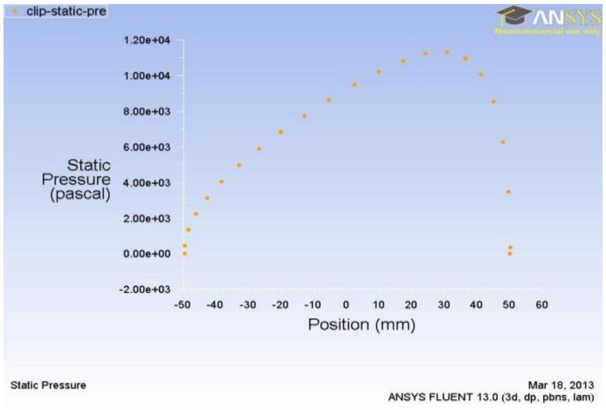

Fig 4: Pressure Distribution for L/D =0.6 at e=0.2 and N=1000 rpm

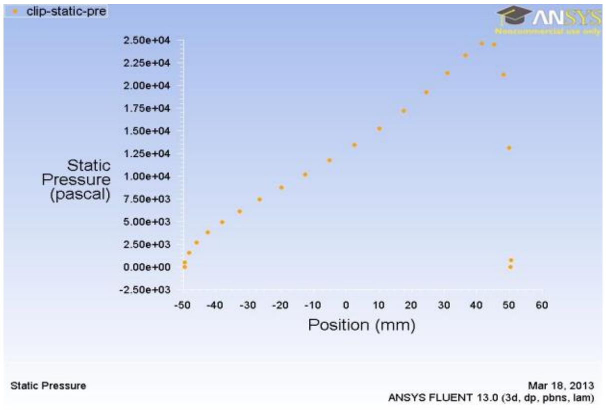

Fig5: Pressure distribution for L/D =0.6 at e=0.35 and N=1000 rpm

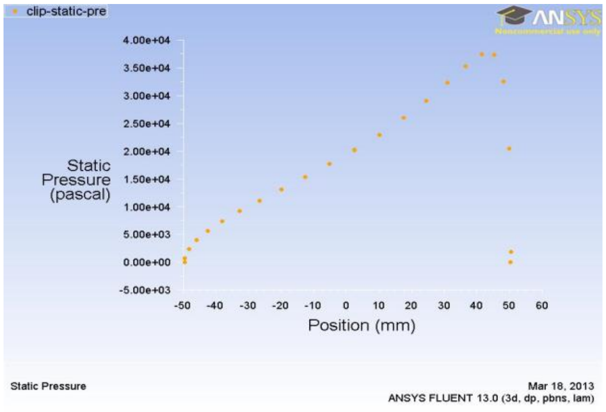

Fig6: Pressure distribution for L/D =0.6 at e=0.35 and N=1500 rpm

6. Conclusion

From the above results, it is cleared that Pressure increases with increase in eccentricity and also increases with increase in angular velocity.It is shown in Fig below

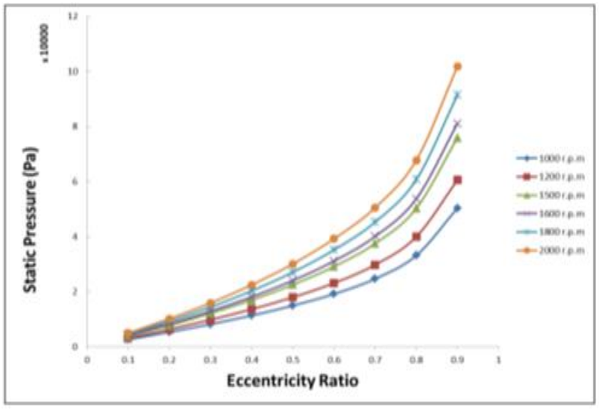

Fig 7: Pressure Variation with eccentricity Ratio and angular velocity

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