Performance Analysis of 3 Lobe Hydrodynamic Journal Bearing

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Abstract— Hydrodynamic journal bearings are widely used due to their high load carrying capacity and good damping properties. The bearing carries higher loads which reduces film thickness and increase pressure of fluid film. The pressure distribution is important in both load capacity estimations and dynamic analysis. We can analyze the pressure of fluid film and total deformation of 3 Lobe hydrodynamic journal bearing by Fluid Structure Interaction technique. The CFD results were compared with experimental results and good agreement were found. It is observed that, pressure and load on bearing increases with increase in rotation speed of journal. This paper describes FSI technique with optimization.

Keywords— Journal Bearing, 3-Lobe Bearing Pressure Distribution, Deformation, CFD, FSI, Optimization

INTRODUCTION

Hydrodynamic journal bearing is defined as a mechanical element which supports high load due to wedge shape geometry formed during the relative motion between journal and bearing surface[1]. Hydrodynamic journal bearing is widely used due to its high load carrying capacity and good damping properties. The major problem with hydrodynamic bearing is failure of fluid film during the operation. This may cause metal to metal contact between journal and bearing surface[2]. This leads to wear and friction which overheats the surfaces. Hence the power loss increases. In this paper FSI technique has been used to predict the performance characteristics of a 3 lobe hydrodynamic journal bearing[3]. The FSI technique can give accurate pressure distribution. The fluent and static structural modules are coupled to generate actual load on shaft and baring inner surface[4]. The optimization technique also used to get optimum results so that bearing can be modified so as to get better results. The bearing is tested on an experimentation setup for various speeds at 600N and 300N loads.

ANALYSIS

The geometry of 3lobe bearing is shown in fig.1. The journal rotates with angular velocity which leads to attitude angle. The journal remains in equilibrium position under action of external load which leads to eccentricity and develops hydrodynamic pressure. The fig.2 shows the fluid film of bearing and oil inlet at upper side of fluid film. The material used for bearing is Aluminum.

Table I
Operating Conditions

Bearing Diameter	72mm
Bearing Length	67.5mm
Journal Diameter	45mm
Radial Clearance	0.3µm
3 Lobes	At 120^o Spacing
Lubricant viscosity	0.0277 Pa. s
Lubricant density	860 Kg/m^3

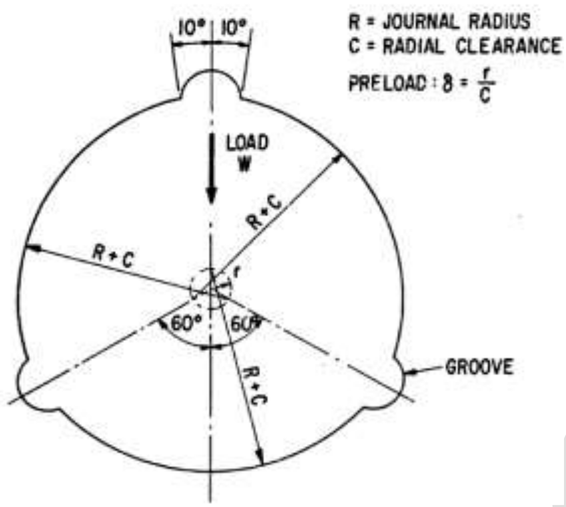

Fig. 1 Geometry of Bearing

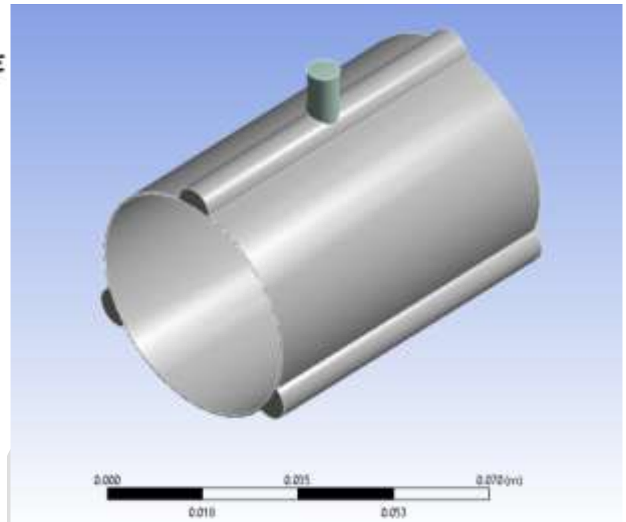

Fig. 2 Fluid Film Geometry in Ansys

The journal has given random offset origin while modeling the geometry. The origin of journal is considered as parameter(X and Y position of origin). The eccentricity and attitude angles also added in parameter set as input with random values. A relation between journal origin, eccentricity and attitude angle is made so that at end of solution we can get value of eccentricity and attitude angle. The meshing of fluid film is done in fluent meshing.

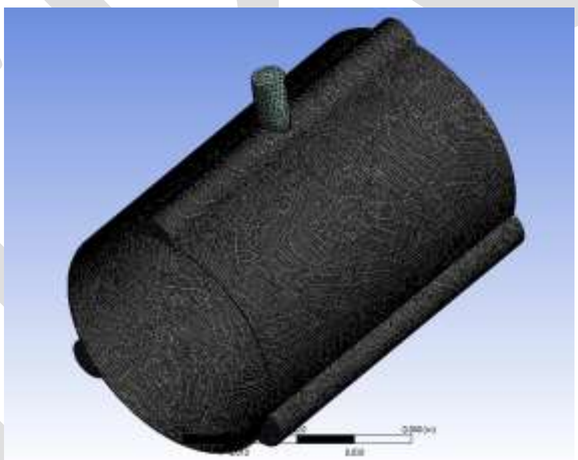

Fig. 3 Fluid Film Meshing

BOUNDARY CONDITIONS

The inner surface of fluid film has considered as shaft and given rotations. The outer surface of fluid film is considered as wall. The inlet from top considered as pressure inlet and film thickness at end of fluid film is considered as outlet of oil.

Table II

Boundary Conditions

FSI wall Bearing	Wall
Shaft (Rotating)	4500 rpm
Pressure Inlet	101325 Pa
Pressure Outlet	0

SOLUTION

The solution has given simple method to solve the analysis. In solution we have to monitor mass flow at inlet and outlet and also we monitor pressure force on shaft in X and Y direction. As we are considering optimization the Fluent and Static Structural are coupled and Response Surface optimization module is attached to both. In optimization the module initially solves the various design points generated in module. The Design of Experiments is the initial step building a Response Surface over the design space. This section describes the selected input parameters and their variation range, the chosen Design of Experiments type, and the generated Matrix of Experiments. The explored design space is defined by the range of variation of the input parameters. The Response Surface is a meta-model built from the Design of Experiments for an efficient exploration of the design space. This section describes the selected type of meta-model, including its properties, the obtained quality, and the generated Response Points and charts. The minimum and maximum section reports the minimum and maximum values for each output parameter. These values are approximations found by the Min-Max Search on the Response Surface. The Optimization is based on Response Surface evaluations. This section describes the chosen Optimization type and the generated candidates and charts. The explored design space is defined by the range of variation of the input parameters eccentricity and attitude angle. After this we get Output Parameter Minimum (Response Surface Optimization system) and Output Parameter Maximum (Response Surface Optimization system).

Candidate Points

	Candidate Point 1	Candidate Point 2	Candidate Point 3
P11 - eccentricity (m)	8.9159E-05	8.9045E-05	8.8906E-05
P12 - attitude (deg)	61.886	60.518	59.446
P6 - xForce (N)	★★★ 560.82	★★★ 559.65	★★★ 554.64

Fig.4 Optimization Result

The solution also gives total deformation of bearing and load on bearing as we are using system coupling. The table below shows all analysis values after completing ansys solution.

Table III
Results

Eccentricity	8.91E^{-05} m
Attitude Angle	61.886^{o}
Maximum Pressure	322172.3 Pa
Load	590 N
Total Deformation	6.3619E^{-8} m
Force Reaction on Bearing	503.9 N

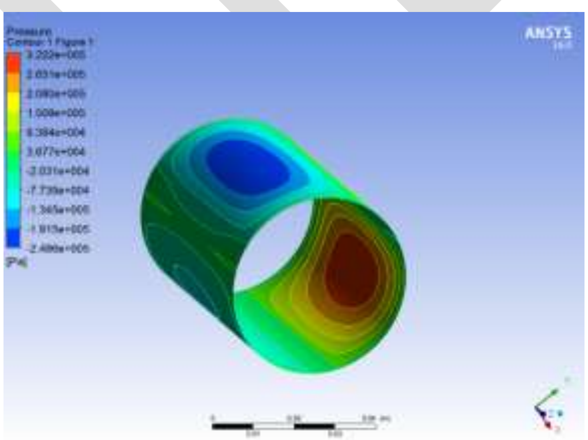

Fig. 5 Pressure Contour of Shaft

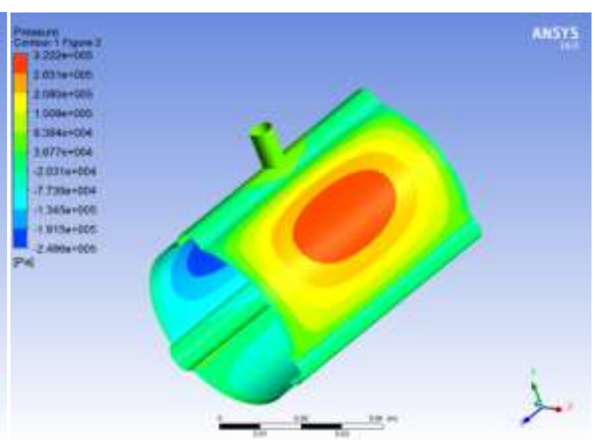

Fig. 6 Pressure Contour of Bearing Inner Surface

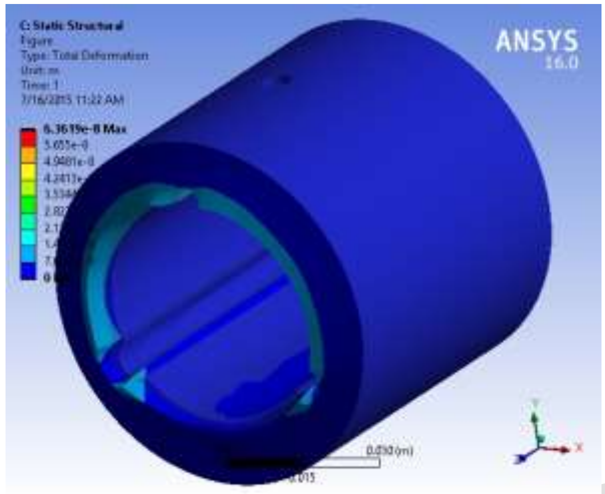

Fig. 7 Deformation of Bearing

EXPERIMENTAL ANALYSIS

From experimental results it was observed that the pressure at pressure sensor number four for both the bearing having maximum value. The negative pressure is observed at sensors six, seven and eight. This negative pressure is nothing but the cavitation occurring inside the bearing due to load and speed. At lower speed and load the pressure on bearing is comparatively lower than higher speed and load. It was also seen that, due to lobes on bearing inner surface the oil flow was maximum from lobe area. It was also seen that the higher pressure occurred at angle between 50^o and 60^o.

The graph is plotted for nine sensor positions on bearing at which are placed at 18 degree spacing. From graph it was observed that the pressure is more at sensor number 4. The maximum pressure is at 4500 rpm as compare to lower rpm. The maximum pressure for 600N load is 2.98 bar and for 300N it is 1.97 bar.

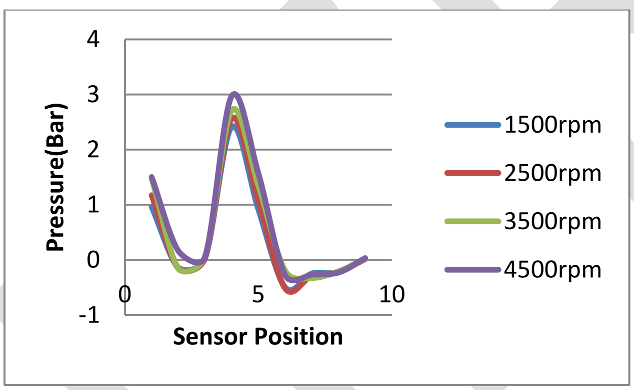

Fig. 8 Graph of Pressure Output at 600N Load

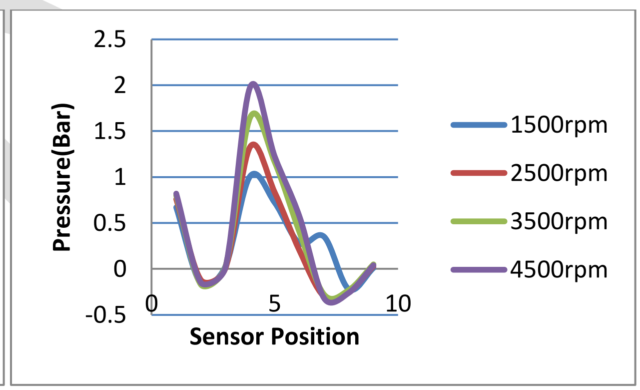

Fig. 9 Graph of Pressure Output at 300N Load

CONCLUSION

The analysis and experimentation result shows that for higher rpm and load, pressure generated is more. The FSI technique gives more accurate analysis of Journal Bearing. The optimization technique can be used to get optimized results of maximum pressure and load on bearing. We can also get value of eccentricity and attitude angle at which we are getting maximum pressure and load on bearing and shaft.

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