Analysis of Hydrodynamic Fixed Pad Bearing to Reduce Vibration by Replacing Flexural Pad in Place of Fixed Pad

Mohinder Kumar Khare[1] Kapil Lakhani[2]
[1]P.G. Student [2]Assistant Professor
[1,2]Department of Mechanical Engineering
[1]Gujarat Technological University, India [2]Veerayatan Group of Institutions, India

Abstract— Rotating machineries are always subject to vibrations due to critical speeds, unbalance, and instability. Usually the least expensive modification of a machine to make is the bearing. A wide variety of bearings have been developed to combat some of the different types of vibration problems. This report consist the analysis of 360deg hydrodynamic bearing of Boiler Feed water Pump. The boiler feed water pump is very critical rotatory equipment of Thermal power plant the bearing of this pump must be able to withstand in vibration and other hydraulic forces while still maintaining a high degree of reliability. This report consist analysis and design of 360 hydrodynamic bearing also replacing fixed pad by flexural pad and analysis bearing vibration and compare vibration for the same condition with the help of FEM Method in ANSYS.

Key words: Hydrodynamic Fixed Pad Bearing, Flexural Pad, Fitted journal bearings

NOMENCLATURE

- c= radial clearance
- D= bearing diameter
- e= eccentricity
- f= friction coefficient
- fm= unit volume value of the induced magnetic force
- h= lubricant film thickness
- hm= magnetic field intensity
- hmo=characteristic value of magnetic field intensity
- J= Jacobian of transformation
- Mg= magnetization of the ferrofluid
- Rs= radius of inner cylinder
- Ro= distance between each grid point and the bearing centre
- ri= radius of outer cylinder
- rw= displaced distance from the wire position to the bearing centre
- Re= Reynolds number
- (u,v)= velocity components in x and y- direction
- (U,V)= velocity components in ξ and η-direction
- V= linear velocity in the inner cylinder
- (x,y)= coordinates in physical domain
- Z= physical plane
- ε= eccentricity ratio = e/c
- ηs= the value of η on the inner cylinder
- θ= angle in direction of rotation
- θi= the half of the span of groove angle
- μ= viscosity
- μo=permeability of free space of air
- ρ= density
- (ξ, η)= coordinates in computational domain
- ϕ= attitude angle
- ψ= position angle of the displaced wire magnetic model
- ω= angular velocity of the inner cylinder.

I. HISTORY

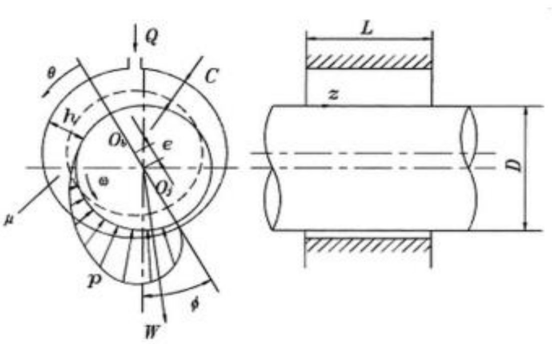
In the late 1880s, experiments were being conducted on the lubrication of bearing surfaces. The idea of "floating" a load on a film of oil grew from the experiments of Beauchamp Tower and the theoretical work of Osborne Reynolds.

A. First Application

In 1912, Albert Kingsbury was contracted by the Pennsylvania Water and Power Company to apply his design in their hydroelectric plant at Hollywood, PA. The existing roller bearings were causing extensive down times (several outages a year) for inspections, repair and replacement. The first hydrodynamic pivoted shoe thrust bearing was installed in Unit 5 on June 22, 1912. At start-up of the 12,000k units, the bearing wiped. In resolving the reason for failure, much was learned about tolerances and finishes required for the hydro-dynamic bearings to operate. After properly finishing the runner and fitting the bearing, the unit ran with continued good operation. This bearing, owing to its merit of running 75 years with negligible wear under a load of 220 tons, was designated by ASME as the 23rd International Historic Mechanical Engineering Landmark on June 27, 1987.

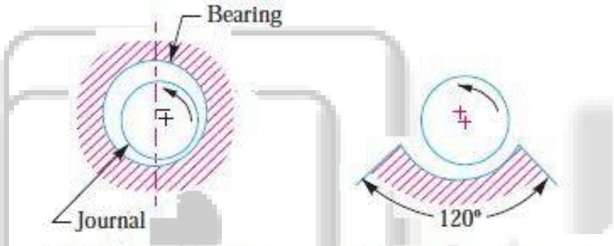
II. INTRODUCTION

Hydrodynamic journal bearings are commonly used in various rotating machines such as pumps, compressors, fans, turbines and generators are widely used in industries. A journal bearing is the most common hydrodynamic bearing in which, a circular shaft, called the journal, is made to rotate in a fixed sleeve is called the bearing. The bearing and the journal operates with a small radial clearance of the order of 1/1000th of the journal radius. The clearance space between the journal and the bearing is assumed to be full of the lubricant. The radial load squeezes out the oil from the journal and bearing face and metal-to-metal contact is established. When the journal begins to rotate inside the bearing, it will climb the bearing surface and as journal speed is further increased; it will force the fluid into the wedge-shaped region. Since more and more fluid is forced into the wedge-shaped clearance space, which begins to exert pressure with increasing journal speed. At a particular speed, the pressure becomes enough to support the load and the closest approach between journal and bearing where the oil film thickness is the minimum.



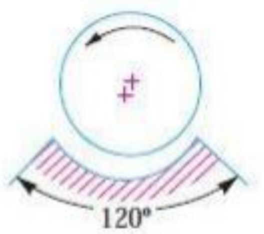
The journal bearing can be classified in to three types according to the angle of the contact between the journal and the bearing as the follows:

- Full journal bearings: When the angle of contact of the bearing with journal is 360°
- It is used in industrial machine so that it can accommodate radial load in any direction.
- Partial journal bearings: When the angle of the contact of the bearing with the journal is 120° but the diameter of the journal not equal to the bearing diameter. Partial journal bearings are used only to accommodate one radial direction and are used in rail road car axles. This type of bearing bear less friction due to small angle of contact.



(a) Full journal bearing. (b) Partial journal bearing.

- Fitted journal bearings: When the angle of the contact of the bearing with the journal is 120° but the diameter of the journal is equal to the bearing diameter.



(c) Fitted journal bearing.

It is often the case in industry that a rotating machine is designed from the point of view of the pressure to be delivered, the flow rate to be delivered, the torque required of the electric motor, and other factors which are independent of vibration considerations. Near the end of the design process the vibration characteristics of the rotor-bearing system are considered. If vibration problems are encountered either in the design stages or testing stages, it is very difficult to redesign the entire rotor at this point. The easiest change to make is often a bearing change. Thus the designer and user of rotating machinery should be acquainted with the fundamentals of the vibration suppression characteristics of a number of different fluid film bearings.

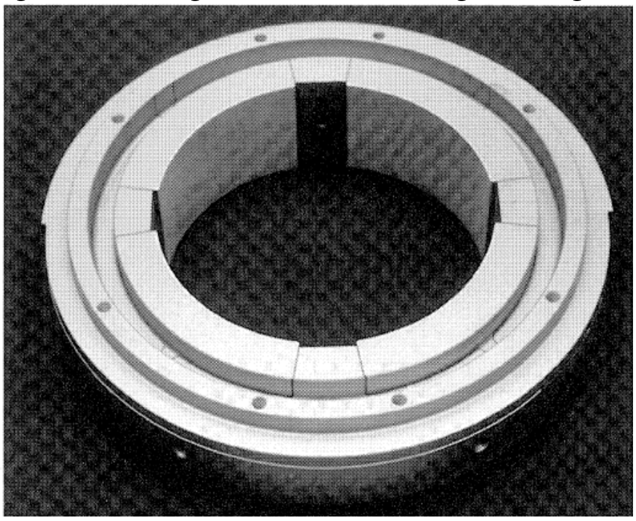
Rotating machines are commonly supported in fluid film hydrodynamic bearings. They have relatively low frictional resistance to turning, but more importantly provide viscous damping to reduce lateral vibrations in these machines. If a given machine configuration were supported in rolling element bearings rather than the fluid film bearings, generally the vibration would be so large as to totally prevent operation of the machine due to vibration. Rolling element bearings provide the stiffness necessary to support the weight of the machine but have essentially zero damping or shock absorbing capabilities.

A number of causes of large vibrations in rotating machinery exist. They include machine unbalance, hydrodynamic journal bearings themselves, interaction with the working fluid in a machine, seals in rotating machines, friction rubs, and internal friction due to stress reversals in shrunk-on parts. Normally, all except the first category, due to machine unbalance, produce large amplitude of vibration in the machine which occurs at a different frequency from that of the rotating frequency. The resulting dynamic shaft motion, called instability, occurs at a frequency less than that of the rotating speed and is called sub synchronous vibration. Many of the bearings described in this article have been developed specifically to combat one or another of the causes of instability indicated above. Usually if a bearing has good damping properties such that it will suppress one of the causes of instability, it will also greatly moderate the other causes as well.

To reduce vibration in high pressure and high flow pumps after completing design process of pump we have only one part the Bearing of Pump for redesign. In this literature we redesign the bearing of pump by replacing its fixed outer race pads by flexural Pads. The flexural pad have more stiffness and shock bearing ability, by using this pad the bearing can absorb sudden load occurs on pad.

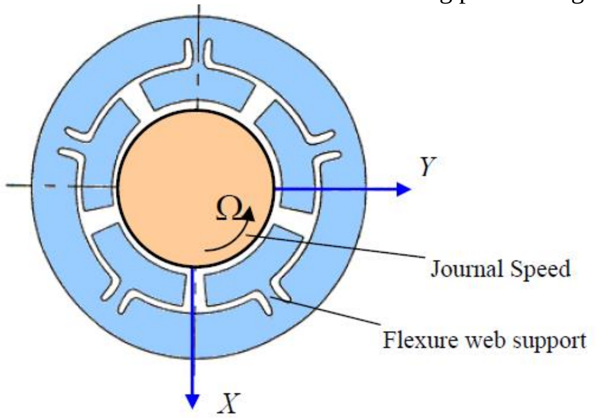
A. Fixed Pads-

The outer race of the bearing is divided in 4 to 6 same sized segments, these segments are fixed in casing of bearing.

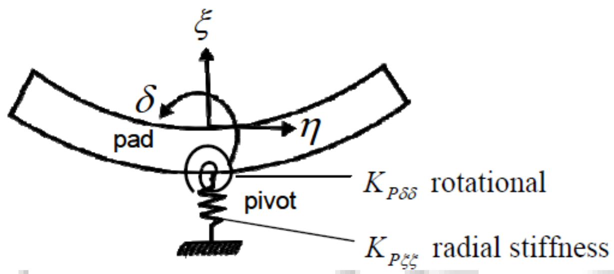


B. Flexural Pads-

It is a two piece configuration that uses electron discharge machining to manufacture the pad, connected by a flexure thin web to the bearing housing. This design eliminates tolerance stack ups that usually occur during manufacturing and assembly, pivot wear, and unloaded pad flutter problems which occur in conventional tilting pad bearings.



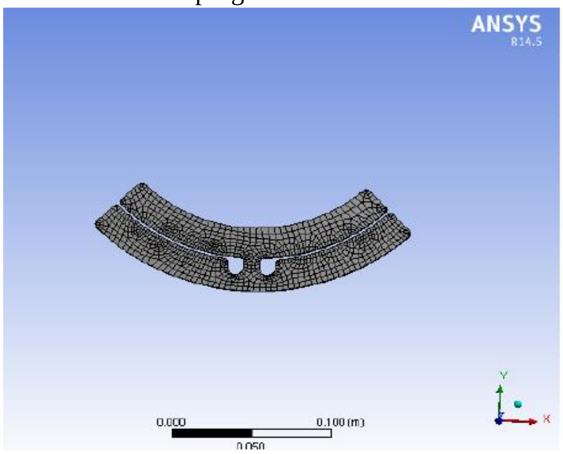
Pivot flexibility makes the pad to displace along the radial (ξ) and transverse (η) directions. The pad also tilts or rotates with angle (δ).



III. Conclusion

From review of above literature we can conclude the following points:

- The stiffness and dumping coefficient may increase.
- Direct stiffness tends to increase with load and Shaft speed.
- In case of large rotors the pivot stiffness and corresponding fundamental flexibility can be significant factor in determination of stability.
- The modeling of a single pad using a state of the art finite element program



The objective for my PG dissertation is to study of Hydrodynamic bearing by replacing fixed pad to flexural pad, and analyze vibration in both the case.

References

[1] Ali Abasabad Arab and Mohammad Abasabad Arab, " Analysis of A Tilting Pad Journal Bearing's Clearance "in Indian J.Sci.Res.1(2) : 165-172, 2014
[2] J C P Carlo and A A S Miranda MSc PhD, Analysis of Hydrodynamic Journal Bearing Considering Lubrication Supply Condition.
[3] Dinesh Dhande, Dr D W Pande , and Vikas Chatarkar "Analysis of Hydrodynamic Journal Bearing Using Fluid Structure Interaction Approach" in International Journal of Engineering Trends and Technology (IJETT) - Volume4 Issue8- August 2013
[4] Dinesh Dhande, Dr D W Pande, and Vikas Chatarkar "Analysis of Pressure for 3lobe Hydrodynamic Journal Bearing" in International Journal of Engineering Trends and Technology (IJETT) – Volume X Issue Y- Month 2013.
[5] Dipl. –ing. Pierre, Dr. Henrich Sprysl and Dr. Gunter Ebi, "Bearing stiffness determination through Vibration Analysis of shaft line of a budron Hydro Power" in International Journal Hydro Power-Dam 1998 Pn-437-447
[6] P. E. Allairi, R. D. Flack, "Design of Journal Bearing of Rotory Machine"
[7] Fabrizio Stefani, "FEM Applied to Hydrodynamic Bearing Design.
[8] Amit Solanki, Prakash Patel, Bhagirath Parmar "Design Formulation and Optimum Load Carrying Capacity of Hydrodynamic Journal Bearing By using Genetic Algorithm" in IJSASET Vol. 2 Issue II, February 2014.
[9] Gregory F Simmons, "Journal Bearing Design, Lubrication and Operation for Enhanced Performance"
[10] Ravindra M Mane and Sandeep Soni, "Analysis of Hydrodynamic Plane Bearing"
[11] Scan M. DeCamillio, Minihui He, C. Hunter Cloud and Jams M. Byrne, "Jornal Bearing Vibration and SSV Hash".
[12] Dr. Luis San Andrés, "Static and Dynamic Forced Performance of Tilting Pad Bearings: Analysis Including Pivot Stiffness" in 2010.
[13] Kyuho Sim and Daejong Kim, "Design and Hydrodynamic Performance of Hybrid Flexural Pivot Gas Bearings for High Speed Oil-Free Micro Turbo machinery" in World Tribology Congress-III, Sept 12-16 2005.
[14] Wen Jeng Chen, "Bearing Dynamics Coefficients of Flexible-Pad Journal Bearing" in Tribology Transactions, Volume 38(1995), 2, 253-260.