ANALYSIS OF ELASTO HYDRO-DYNAMIC LUBRICATION OF CIRCULAR JOURNAL BEARING

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ABSTRACT

In this paper the study is to determine the journal bearing lubrication characteristic's such as pressure distribution and oil film thickness. These characteristic can be found out by solving the equation that govern the fluid structure interaction occurring between journal bearing, The pressure distribution of the lubricating oil is determined by solving Navier Stroke equation; the momentum equation gives velocity plots. Which one used to get the pressure distribution plots by solving pressure Poisons equation. The pressure distribution obtained from Navier stroke is used to find out the force and displacement by solving the stresses and relations. The pressure profile of lubricating oil are determined by considering SAE20W lubricating oil different eccentricity value and same length-diameter ratio of journal bearing .The analysis is also carried out for material like aluminum different eccentricity value and same length-diameter ratio and the eccentricity value varies from 0.2, 0.4, 0.6, and 0.8 and by considering constant length to diameter ratio as 2.4 for SAE20W oil and result for pressure distribution found for different eccentricity are 34752.08 N/m^2 35243.09 N/m^2 35849.03 N/m^2 and 36262.12 N/m^2.

Keyword: *- journal bearing1, CFD2, CSD3, ANSYS4, SAE20Woil5, aluminium6, L/D Ratio7and eccentricity.etc*

1. INTRODUCTION

The part which is enclosed by and rubs against the other is called the journal and the part which encloses the journal is called the bearing. Mostly the journal rotates in the fixed bearing but in a few cases both the journal and bearing are in motion, for example a crack pin and it's bearing in the connecting rod. In some cases the journal is fixed and the bearing rotates as in a hoisting drum or a loose pulley.

Lubrication is the science of reducing friction by application of a suitable substance called lubricant, between the rubbing surfaces of bodies having the relative motion.

The object of the lubricant is as follows:

- Reduce the friction.
- To reduce or prevent wear.

- A lubricant is any substances that, when inserted between the moving surfaces, accomplishes the above objectives.
- In a sleeve bearing a shaft or journal rotates or oscillates within a sleeve, or bushing, and the relative motion is sliding.

1.1 TYPES OF LUBRICATION:

Five different form of lubrication may be identified:

1. Hydrodynamic lubrication
2. Hydrostatic lubrication
3. Elasto-hydrodynamic lubrication
4. Boundary

5. Solid film.

Hydrodynamic lubrication :In which the fluid film pressure is generated only by the rotation of the journal, the journal taking up a position in the bearing so that its rotation is able to produce a continuous film of lubricant in which there is sufficient change of pressure to produce a force which will support the journal load. Or the load-carrying surface of the bearing are separated by a relatively thick film of lubricant, so as to prevent metal to metal contact, and the stability thus obtained can be explained by the laws of fluid mechanics.

Hydrostatic lubrication: In which the fluid film pressure is obtained by applying the lubricant at a high pressure through set of holes in the bearing shell positioned so that the force exerted by the pressurized lubricant the loaded journal at all times.

Elasto-hydro dynamic lubrication: In which the elastic deformation of the parts must be taken into account as well as the increase in viscosity of the lubricant due to high pressure. This small elastic flattering parts together with increase in viscosity provides a film, although very thin, that is much thicker than would prevail with completely rigid parts. Or the phenomenon that occurs when a lubricant is introduced between surface that are in rolling contact, such as mating gears or rolling bearing. The mathematical explanation requires the Hertzian theory of contact stress and fluid mechanics.

Boundary lubrication, when insufficient surface area : A drop in the velocity of the moving surface, a lessening in the quantity of lubricant delivered to a bearing, or an increase in lubricant temperature resulting in a decrease in viscosity-anyone one of these may prevent the buildup of a film thick enough for full-film lubrication.

Solid-film lubricant: when bearings operate at extreme temperatures, such as graphite or molybdenum disulfide must be used because the ordinary minerals oils are not satisfactory.

1.2 Bearing friction:

The phenomenon of bearing friction is explained by Petroff's equation on the assumption that the shaft is concentric. Because the coefficient of friction predicted by this law, it turns out to be quite good even when the shaft is not concentric.
Consider a shaft rotating in a guide bearing as shown in fig

- Assumptions holds good
- The bearing carries a very small load,
- The clearance space is completely filled with oil,
- The leakage is negligible.

We denote
The radius of shaft by = r
The radial clearance by= c
And the length of the bearing by= l
If the shaft rotates N rev/s, then its surface velocity is U= 2prN

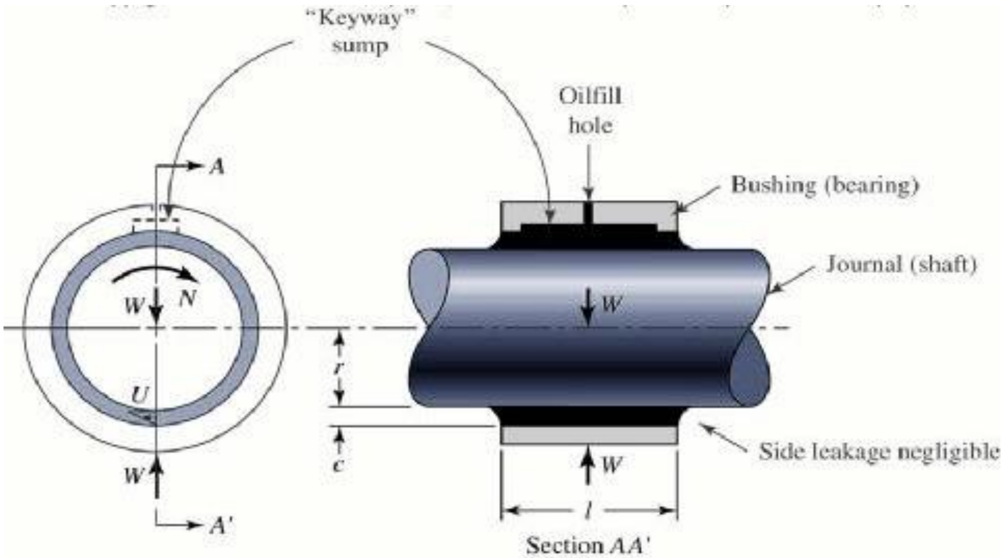


Fig -1: model of journal bearing.

2. Governing Equations in CFD:

(i) Continuity equation:

$$\frac{\partial u}{\partial x}+\frac{\partial v}{\partial y}+\frac{\partial w}{\partial z}=0$$

(ii) Momentum equations

a. X-momentum equation

$$\rho\,(u\,\frac{\partial u}{\partial x}+\text{v}\frac{\partial v}{\partial y}+\text{w}\frac{\partial w}{\partial z}) = -\frac{\partial p}{\partial x}+\mu\,(\frac{\partial^2 u}{\partial x^2}+\frac{\partial^2 \text{u}}{\partial y^2}+\frac{\partial^2 u}{\partial z^2})$$

(b) Y-momentum equation

$$\rho\,(u\,\frac{\partial u}{\partial x}+\text{v}\frac{\partial v}{\partial y}+\text{w}\frac{\partial w}{\partial z}) = -\frac{\partial p}{\partial y}+\mu\,(\frac{\partial^2 u}{\partial x^2}+\frac{\partial^2 \text{u}}{\partial y^2}+\frac{\partial^2 u}{\partial z^2})$$

(c) Z-momentum equation

$$\rho\,(u\,\frac{\partial u}{\partial x}+\text{v}\frac{\partial v}{\partial y}+\text{w}\frac{\partial w}{\partial z}) = -\frac{\partial p}{\partial z}+\mu\,(\frac{\partial^2 u}{\partial x^2}+\frac{\partial^2 \text{u}}{\partial y^2}+\frac{\partial^2 u}{\partial z^2})$$

(iii) Energy equation:

$$(u\,\frac{\partial T}{\partial x}+\text{v}\frac{\partial T}{\partial y}+\text{w}\frac{\partial T}{\partial z}) = \frac{1}{\alpha}\,(\frac{\partial^2 T}{\partial x^2}+\frac{\partial^2 \text{T}}{\partial y^2}+\frac{\partial^2 T}{\partial z^2})$$

In the ELASTO hydro dynamic lubrication bearing, oil pressure is calculated by solving NAVIER-STROKE equation corresponding to fluid flow region subjected to boundary conditions. In order to get the numerical solution, journal bearings are modelled using Elasto hydro dynamic model and the solution are obtained by using finite volume method. For this the commercially available fluid flow solver ANSYS FLUENT is used. Geometrical model is prepared using PRO/E CAD software and is then imported to fluent software. FLUENT solver gives numerical solution for given bearing loading subjected to boundary conditions.

2.2 EHL journal bearings are modeled in PRO/E using geometrical data shown in below:

Table -1 DETAILS OF CIRCULAR JOURNAL BEARING

Journal radius	0.05 m
Radial clearance	50 µm
Bearing pad thickness	0.005 m
L/D ratio	2.4
Eccentricity ratio	0.2,0.4,0.6and 0.8

The geometrical models of EHL journal bearings are shown figures

1. L/D =2.4 AND ε =0.2

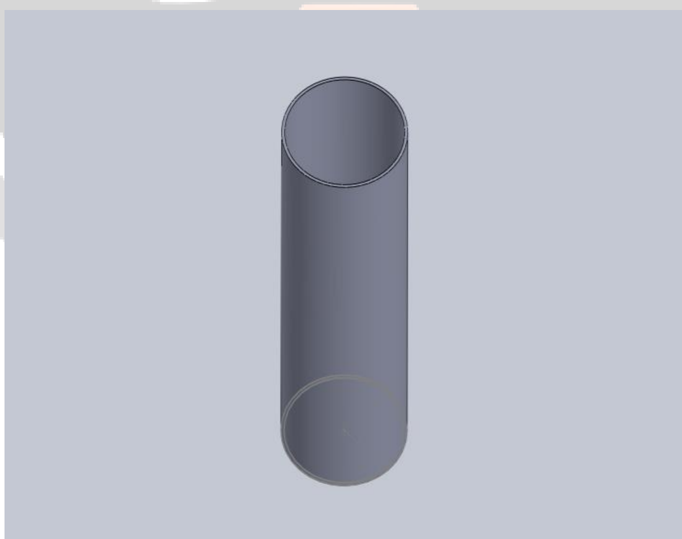


Fig -2: model of journal bearing for constant l/d 2.4 and eccentricity 0.2

2. L/D =2.4 AND ε =0.4

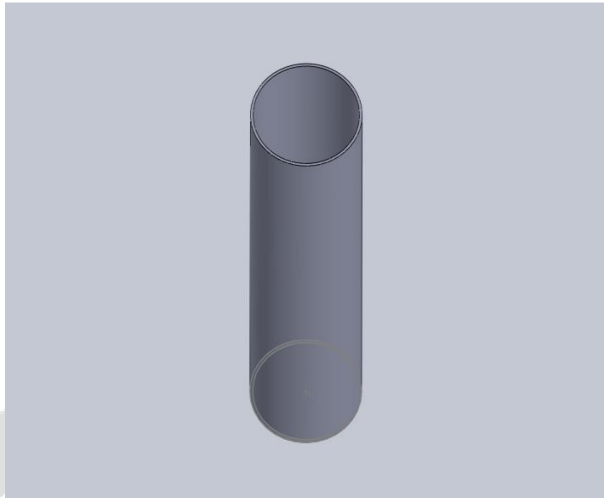


Fig -3: model of journal bearing for constant l/d 2.4 and eccentricity 0. **4**

3. L/D =2.4 AND ε =0.6

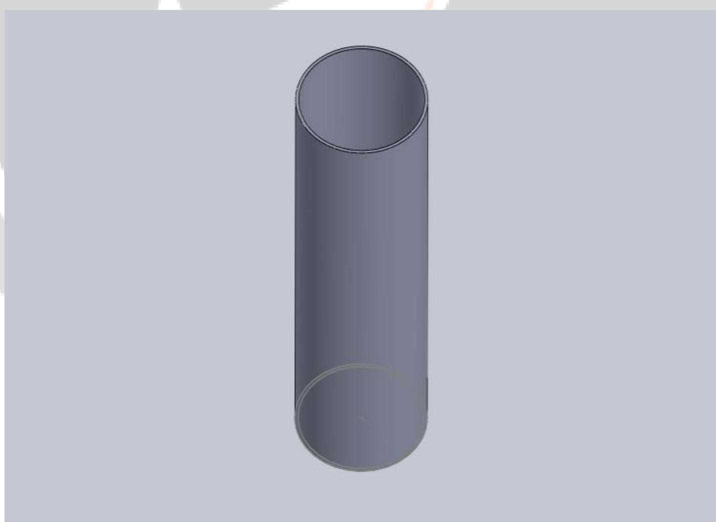


Fig -4: model of journal bearing for constant l/d 2.4 and eccentricity 0. **6**

5. L/D=2.4 AND ε =0.8

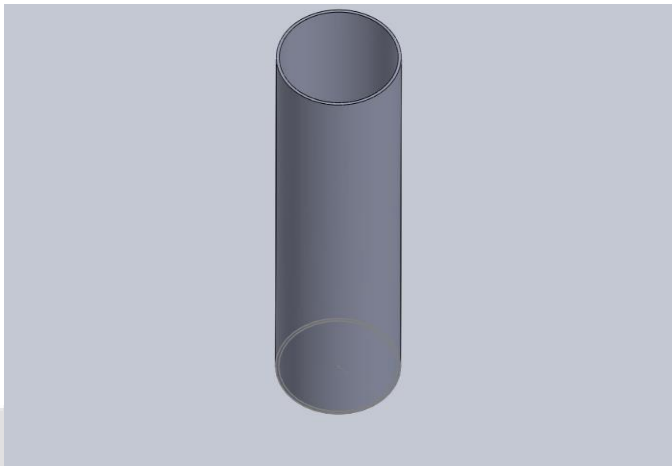


Fig -5: model of journal bearing for constant l/d 2.4 and eccentricity 0.8

2.3 LUBRICTING OILS:

Lubricating oils are divided into two groups:

- Mineral oils.
- Vegetable or animal oils.

Mineral oils consist of hydrocarbons, which are obtained by the distillation of crude oil. There are two different classes of mineral oil those with a paraffinic series and those with a naphthenic series.

The society of automotive engineer (SAE) of USA has classified lubricating oil by number, which is released to the viscosity of the oil in say bolt universal seconds; this classification is based on only one property of lubricating oils, namely viscosity.

Table -2: SAE2OW OIL PROPERTIES:

Density	872 kg/m^3
Specific heat	19252.96 j/kg k
Thermal conductivity	0.136 w/m k
Viscosity	18.7 centistokes.

3. RESULTS AND DISCUSSION:

In the present project work journal bearing is analysed using Elasto hydro dynamic model in order to find the pressure field and deformation of bearing mating surfaces analysis fluid dynamics and fluid structure interaction approaches. The commercial available ANSYS fluent software is used to predict oil film pressure defo rmation and stresses occurring in mating surfaces using SAE20W oil.

1. L/D = 2.4 and ε = 0.2

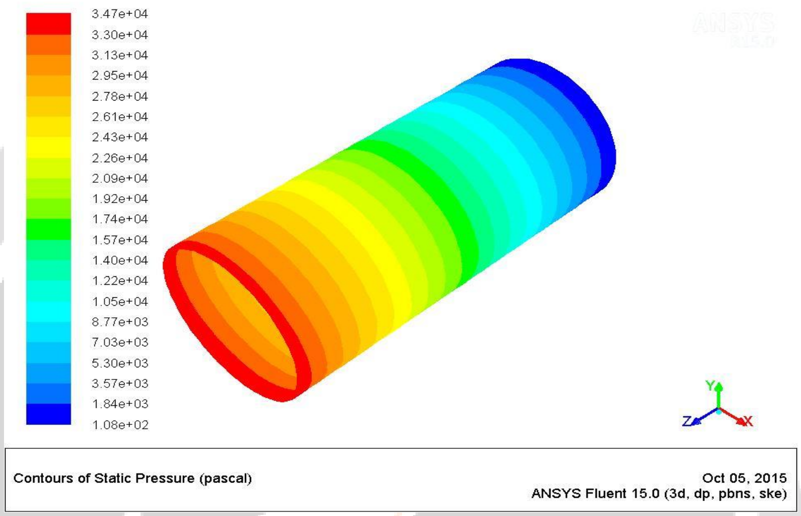


Fig -6: Pressure profile for L/D = 2.4 AND eccentricity 0.2 for SAE20W oil.

2. L/D = 2.4 and ε = 0.4

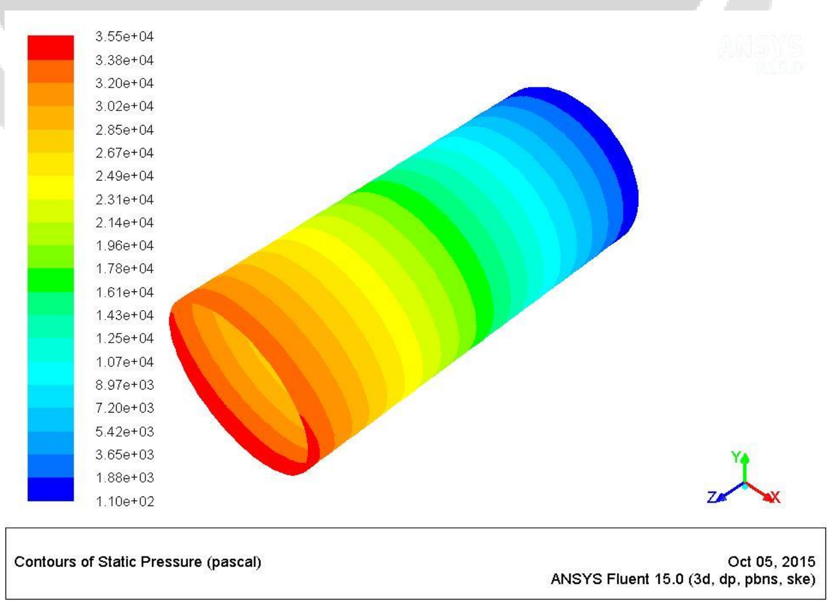


Fig -7: Pressure profile for L/D = 2.4 AND eccentricity 0.4 for SAE20W oil.

3. L/D = 2.4 and ε = 0.6

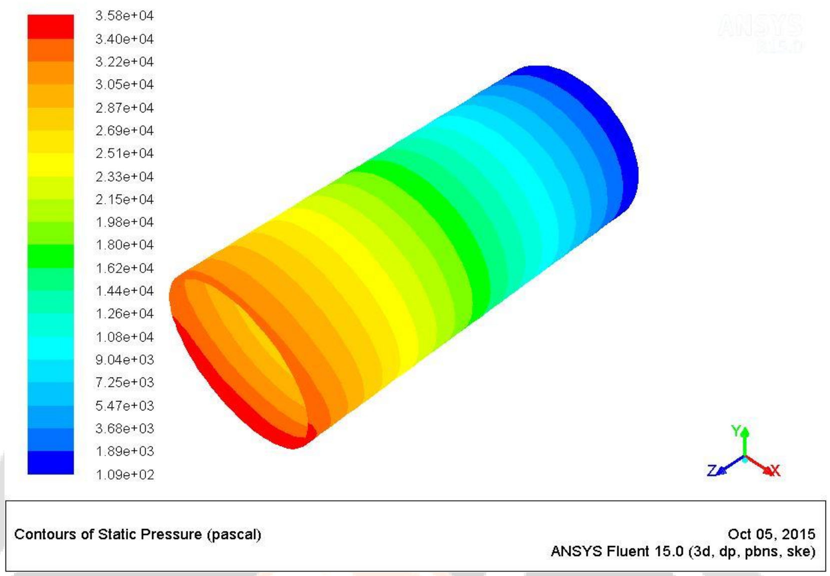


Fig -8: Pressure profile for L/D = 2.4 AND eccentricity 0.6 for SAE20W oil.

4. L/D = 2.4 and ε = 0.6

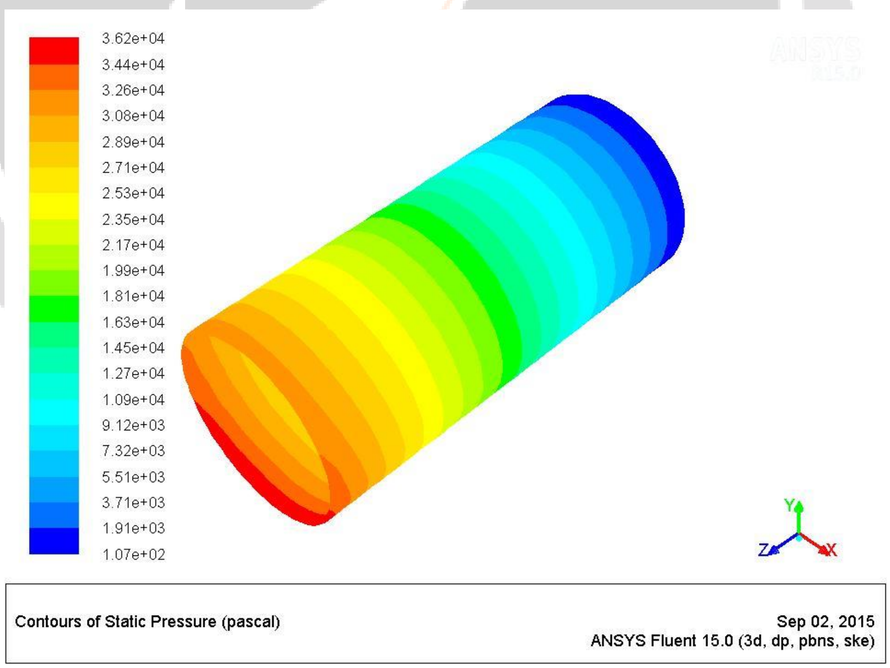
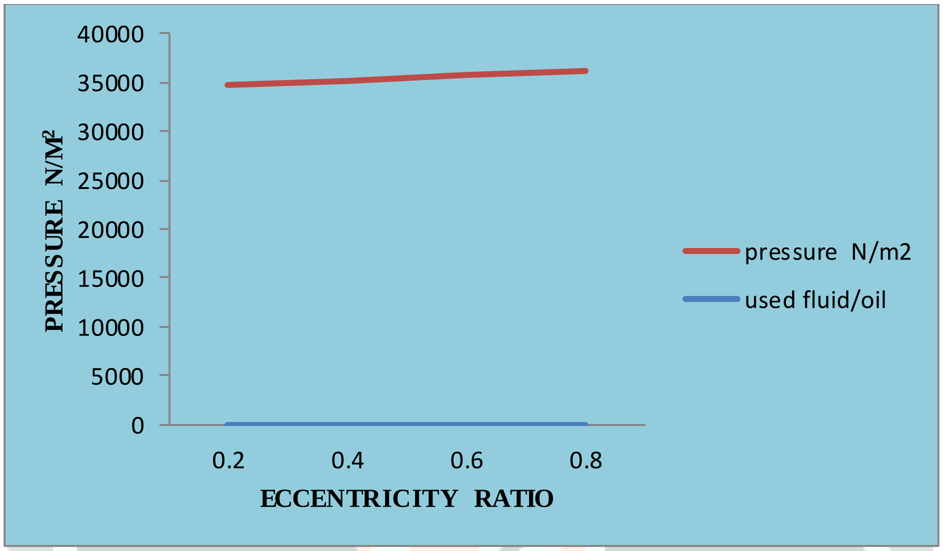


Fig -9: Pressure profile for L/D = 2.4 AND eccentricity 0.8 for SAE20W oil.

3.1 Graphic representation for SAE20W for different eccentricity value



4. CONCLUSION:

The overall Elasto-hydro dynamic lubrication (EHL) analysis of circular journal bearing has been conducted using computational fluid dynamics (CFD)

The CFD and structural analysis is done on different models using ANSYS in order to evaluate the fluid pressures, Different models of journal bearing are designed by eccentricity ratios as 0.2, 0.4, 0.6 and 0.8 and keeping constant L/D ratios 2.4 and. 3D modeling is done in Pro/Engineer. CFD and structural analysis is done in ANSYS.

By observing the CFD analysis results, the pressure is increasing by increasing the eccentricity for constant L/D ratios.

5. REFERENCES:

[1]. Dinesh Dhande, Dr.D W Pande, VikasChatarkar "Analysis of Hydrodynamic Journal Bearing Using Fluid Structure Interaction Approach' 'International Journal of Engineering Trends and Technology (IJETT) - Volume4 Issue8- August 2013 ISSN: 2231-5381.
[2]. B. S. Shenoy_, R. S. Pai, D. S. Rao, R. Pai "Elasto-hydrodynamic lubrication analysis of full 360_ journal bearing using CFD and FSI techniques'' Department of Mechanical and Manufacturing Engineering, Manipal Institute of Technology, Manipal, Karnataka 576104, India. ISSN 1 746-7233, England, UK World Journal of Modelling and Simulation Vol. 5 (2009) No. 4, pp. 315-320.
[3]. Ravindram.mane,Sandeepsoni " Analysis of hydrodynamicplainjournal bearing'' SardarVallabhbhai National Institute of Technology, Surat, Gujarat, India-395007. Excerpt from the Proceedings of the 2013 COMSOL Conference in Bangalore.

[4]. PriyankaTiwari, Veerendra Kumar "Analysis of Hydrodynamic Journal Bearing Using CFD and FSI Technique''International Journal of Engineering Research&Technology (IJERT) ISSN: 2278-0181 Vol. 3 Issue 7, July – 2014.
[5]. BasimAjeelAbass, SudadNoriGhani "Effect of Bearing Elastic Deformation on the Turbulent Thermo hydrodynamic Lubrication of Misaligned Plain Journal'' Nahrain University, College of Engineering Journal (NUCEJ) Vol.17 No.1, 2014 pp. 91-108.
Bearings
[6]. M. Mongkolwongrojn, P. Cumphunyim Department of Mechanical Engineering, ReCCIT, Faculty of Engineering King Mongkut's Institute of Technology Ladkrabang Bangkok 10520 ETM043.
[7]. L. Dammak and E. Hadj-Taïeb "Finite Element Analysis of Elastohydrodynamic Cylindrical Journal Bearing'' FDMP, vol.6, no.4, pp.419-429, 2010.
[8]. AmitChauhan, AmitSingla, NarenderPanwar and Prashant Jindal "CFD Based Thermo-Hydrodynamic Analysis of Circular Journal Bearing'' International Journal of Advanced Mechanical Engineering. ISSN 2250-3234 Volume 4, Number 5 (2014), pp. 475-482.
[9]. Ron A.J. van Ostayen[a,], Anton van Beek[a], Mink Ros[b] "A mathematical model of the hydro-support: an elasto-hydrostatic thrust bearing with mixed lubrication''

[10]. Samuel Cupillard, Michel J. Cervantes and Sergei Glavatskih "a CFD study of a finite textured journal bearing iahr24th Symposium on Hydraulic Machinery and Systems october 27-31, foz do iguassu.
[11]. K.P. Gertzos, P.G. Nikolakopoulos, C.A. Papadopoulos "CFD analysis of journal bearing hydrodynamic lubrication by Bingham lubricant''.