INTERNATIONAL JOURNAL OF TECHNO-ENGINEERING
IJTE

ISSN: 2057-5688

DESIGN & ANALYSIS OF JOURNAL BEARING

RUDRA KRISHNA[a], Mr. ASHWAK AYUB[b]

M.Tech in mechanical engineering at Holy Mary Institute of Technology & Science

Assistant Professor at Holy Mary Institute of Technology & Science

A B S T R A C T

Journal bearings have the longest history of scientific study of any class of fluid film bearings. In a fluid film bearing, the pressure in the oil film satisfies the Reynolds equation which intern is a function of film thickness. Structural distortion of the housing and the development of thermo hydrodynamic pressure in a full journal bearing are strongly coupled thus require a combined solution.Oil film pressure is one of the key operating parameters describing the operating conditions in thermo hydrodynamic journal bearings. Thermo hydrodynamic journal bearings are analyzed by using Computational fluid dynamics (CFD) and fluid structure interaction (FSI) approach in order to find deformation of the bearing.In this thesis journal bearings for different L/D ratios and eccentricity ratios are modeled in 3D modeling software CREO. The L/D ratios considered are 0.5 and eccentricity ratios considered are 0.8, 1.0, 1.5.Journal bearing models are developed for speed of 2500 rpm to study the interaction between the fluid and elastic behavior of the bearing. The speed is the input for CFD analysis and the pressure obtained from the CFD analysis is taken as input for structural analysis.Computational fluid dynamics (CFD) and fluid structure interaction (FSI) is done in Ansys.

Key words: journal bearing, Aluminium Alloy, FSI technic, CREO, Ansys Workbench, etc.

INTRODUCTION

BEARINGS:

Bearings enhance the functionality of machinery and help to save energy. Bearings do their work silently, in tough environments, hidden in machinery where we can't see them. Nevertheless, bearings

ISSN: 2057-5688

are crucial for the stable operation of machinery and for ensuring its top performance.The word "bearing" incorporates the meaning of "to bear," in the sense of "to support," and "to carry a burden." This refers to the fact that bearings support and carry the burden of revolving axles.

Rolling bearings are made up of four elements and have an extremely simple basic structure they are :

1. Outer ring
2. Inner ring
3. Rolling elementscage

The basic function of bearings is principally to reduce mechanical friction. Reducing friction means:

1. machinery will run more efficiently
2. there will be less frictional wear, extending the operating life of the machinery

ISSN: 2057-5688

3. preventing abrasion burn, avoiding mechanical breakdown

Bearings also contribute to lower energy consumption by reducing friction and allowing the efficient transmission of power. This is just one way in which bearings are environmentally friendly.

1.2 BEARING TYPES:

1. **Deep groove ball bearing**

This is the most widely used bearing in the world.

Deep groove, or single row radial, ball bearings are the most widely used bearings. They utilize an uninterrupted raceway that makes them optimal for radial loads. This design permits precision tolerance, even at high-speed operation.

NTN ball bearings use standard cages of pressed steel, as well as machined, brass cages for high-speed applications. NTN also offers bearings with locating snap rings.

2. **Angular contact thrust ball bearing**

In this type, the rolling element meets the inner and outer ring raceways at a contact angle. This

ISSN: 2057-5688

bearing can carry radial and axial loads.

An angular contact ball bearing uses axially asymmetric races. An axial load passes in a straight line through the bearing, whereas a radial load takes an oblique path that tends to want to separate the races axially. So the angle of contact on the inner race is the same as that on the outer race. Angular contact bearings better support "combined loads" (loading in both the radial and axial directions) and the contact angle of the bearing should be matched to the relative proportions of each. The larger the contact angle (typically in the range 10 to 45 degrees), the higher the axial load supported, but the lower the radial load. In high speed applications, such as turbines, jet engines, and dentistry equipment, the centrifugal forces generated by the balls changes the contact angle at the inner and outer race.

LUBRICATION

Lubrication is the process or technique employed to reduce friction between, and wear of one or both, surfaces in close proximity and moving relative to each other, by interposing a substance called a lubricant between them. The lubricant can be a solid, (e.g. Molybdenum disulfide MoS_2) a solid/liquid dispersion, a liquid such as oil or water, a liquid-liquid dispersion (a grease) or a gas.

With fluid lubricants the applied load is either carried by pressure generated within the liquid the due to the frictional viscous resistance to motion of the lubricating fluid between the surfaces, or by the liquid being pumped under pressure between the surfaces.

Lubrication can also describe the phenomenon where reduction of friction occurs unintentionally, which can be hazardous such as hydroplaning on a road.

LITERATURE REVIEW

B. S. Shenoy[1],etal Conventional method of performing an EHL analysis on a bearing involves development of complex codes and simplification of actual physical model. This paper presents a methodology to model and simulate the Overall Elasto-Thermo hydrodynamic Lubrication of a full journal bearing using the sequential application of Computational Fluid Dynamics (CFD) and Computational Structural Dynamics (CSD). Here, the coupled field analysis uses the capabilities of commercially available Finite Element Software.ANSYS/FLOTRAN incorporating the technique

ISSN: 2057-5688

of Fluid Structure Interaction (FSI). The pressure field for a full journal bearing operating under laminar flow regime with various L/D ratios is obtained by CFD. Stress distribution and deformation in the bearing liner due to resulting pressure force is evaluated using FEM, satisfying the boundary conditions. The stress distribution indicates the critical points in the bearing structure. The results show reasonable agreement in general.

METHODOLOGY

PRO/ENGINEER WILDFIRE BENEFITS

- Unsurpassed geometry creation capabilities allow superior product differentiation and manufacturability
- Fully integrated applications allow you to develop everything from concept to manufacturing within one application
- Automatic propagation of design changes to all downstream deliverables allows you to design with confidence
- Complete virtual simulation capabilities enable you to improve product performance and exceed product quality goals
- Automated generation of associative tooling design, assembly instructions, and machine code allow for maximum production efficiency

Pro ENGINEER can be packaged in different versions to suit your needs, from Pro/ENGINEER Foundation XE, to Advanced XE Package and Enterprise XE Package, Pro/ENGINEER Foundation XE Package brings together a broad base of functionality. From robust part modelling to advanced surfacing, powerful assembly modelling and simulation, your needs will be met with this scaleable solution. Flex3C and Flex Advantage Build on this base offering extended functionality of you're choosing.

DIFFERENT MODULES IN PRO/ENGINEER

- PART DESIGN
- ASSEMBLY
- DRAWING
- SHEETMETAL

ISSN: 2057-5688

METHODOLOGY

4.1Journal bearing Nomenclature

L	Length of the journal bearing mm
D	Diameter of the journal bearing, mm
C	Radial clearance, mm
e	Eccentricity, mm
Ɛ	Eccentricity ratio

In this thesis journal bearings for different L/D ratios and eccentricity ratios are modeled in 3D modeling software Pro/Engineer. The L/D ratio considered are 0.5 and eccentricity considered are 0.8, 1.0and 1.5.Journal bearing models are developed for speeds of 2500 &5000 rpm to study the interaction between the fluid and elastic behavior of the bearing. The speed is the input for CFD analysis and the heat transfer rate obtained from the CFD analysis is taken as input for thermal analysis.Computational fluid dynamics (CFD) and fluid- solid-interaction (FSI) is done in ANSYS.

PROBLEM IDENTIFIED:

Oil film pressure is one of the key operating parameters describing the operating conditions in thermo hydrodynamic journal bearings. Thermo hydrodynamic journal bearings are analyzed by using Computational fluid dynamics (CFD) and fluid solid interaction (FSI) approach in order to find deformation of the bearing.

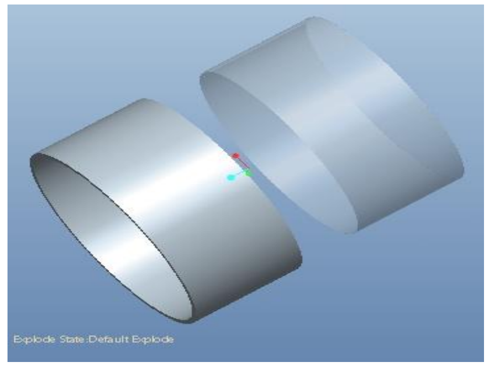
Models of journal bearing using pro-e wildfire 5.0

The journal bearing is modeled using the given specifications and design formula from data book. The isometric view and exploded view of journal bearing are shown in below figure. The profile is sketched in sketcher and then it is extruded up to 50mm, 100mm and 150mm (face width) using extrude option.

INTERNATIONAL JOURNAL OF TECHNO-ENGINEERING
IJTE

ISSN: 2057-5688

L/D=0.5;Ɛ=0.8



ANALYSIS OF JOURNAL BEARING - FSI (FLUD SOLID INTERFACE)

L/d ratio=0.5

Eccentricity (e) =0.8, 1.0&1.5

Fluid – air & helium

Bearing material - babbit

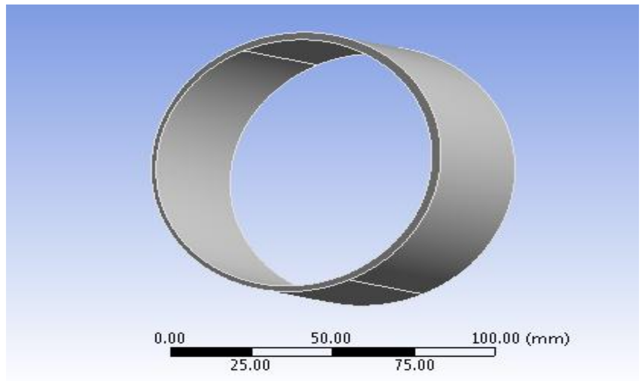
BOUNDARY CONDITIONS

For CFD analysis, velocity and pressure are applied at the inlets. For thermal analysis, the boundary conditions are the pressure obtained from the result of CFD analysis and displacement.

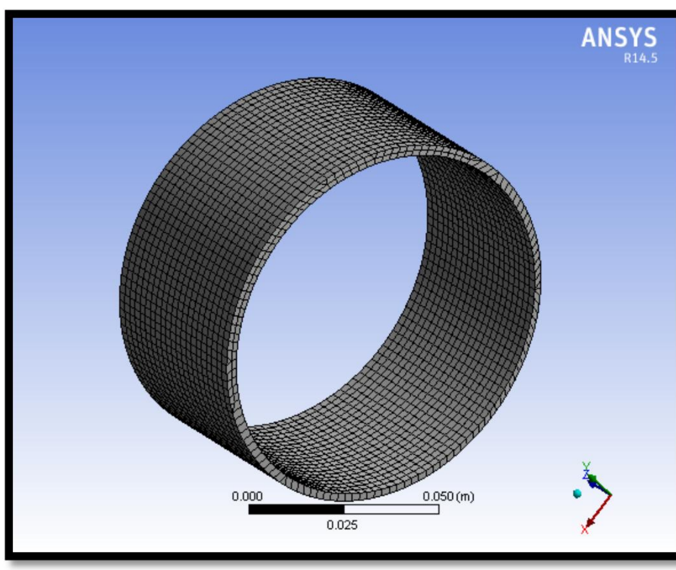
When L/D =0.5 & ECCENTRICITY=0.8

Import geometry

INTERNATIONAL JOURNAL OF TECHNO-ENGINEERING
IJTE
ISSN: 2057-5688

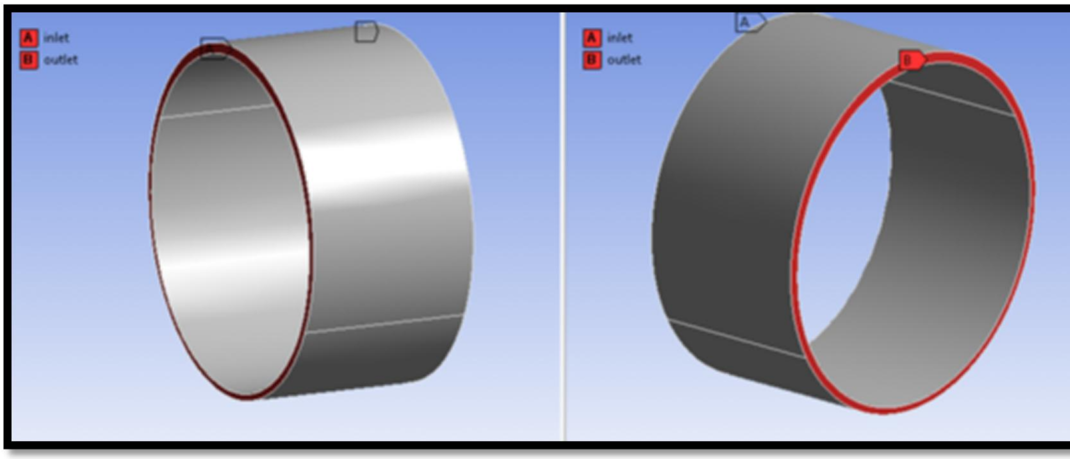


Meshing

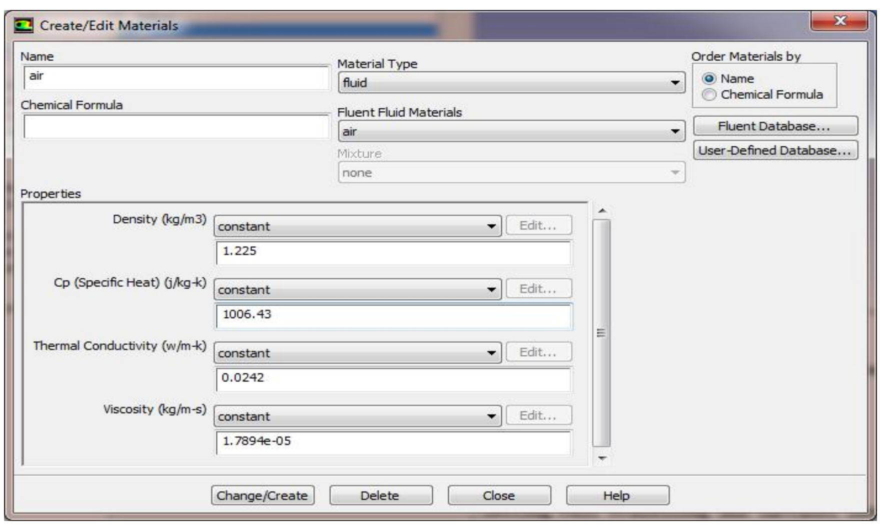


Boundary conditions

ISSN: 2057-5688

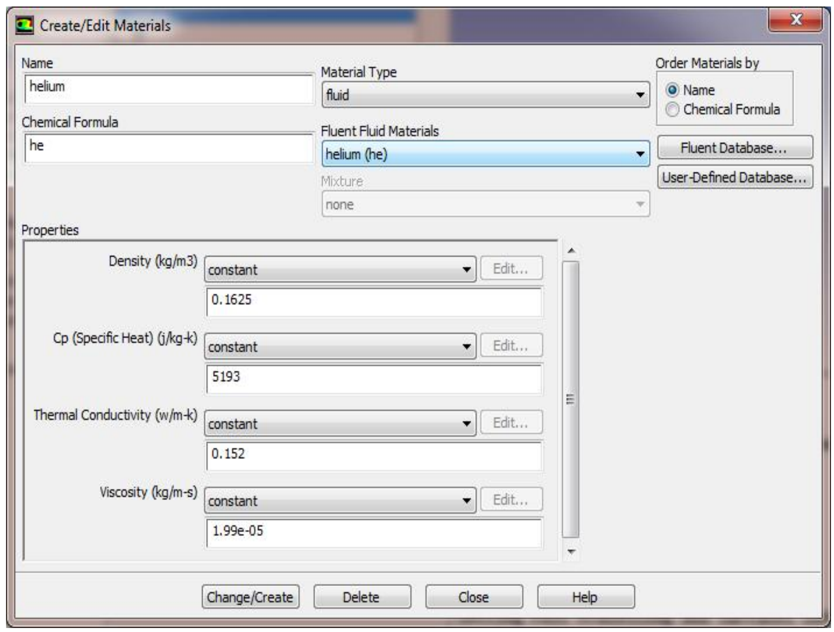


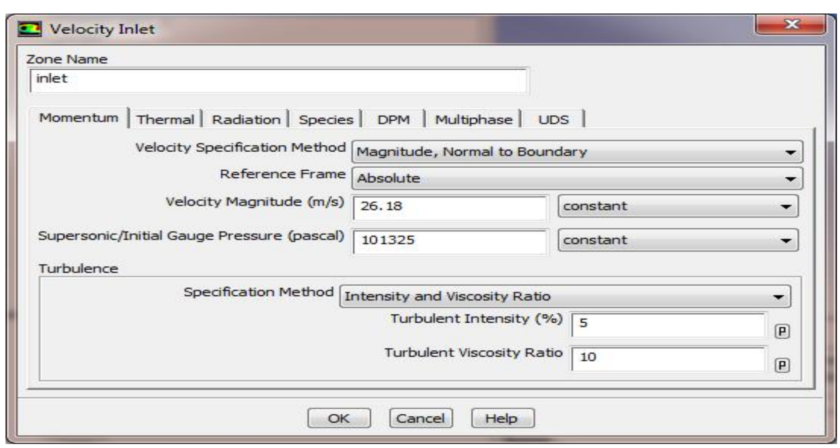
Inlet velocity



INTERNATIONAL JOURNAL OF
TECHNO-ENGINEERING
IJTE

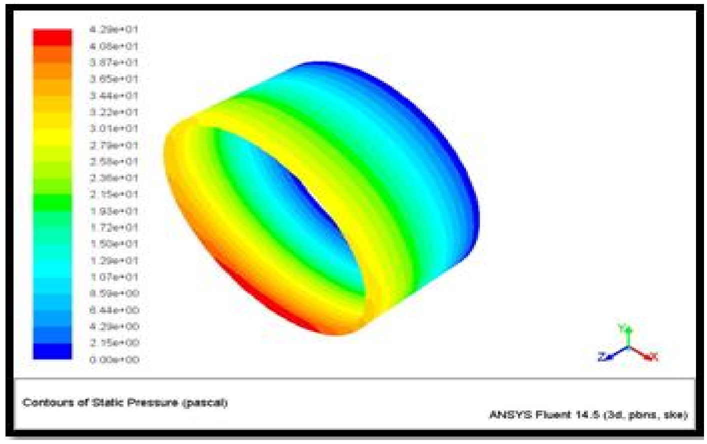
ISSN: 2057-5688



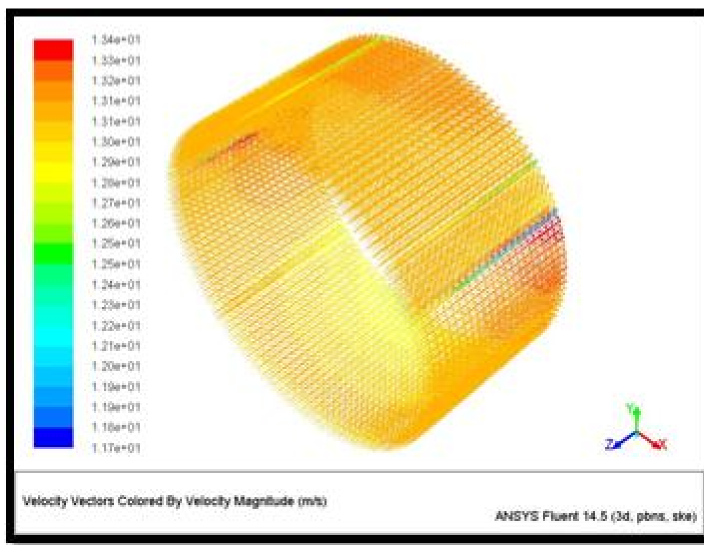


Pressure countours

INTERNATIONAL JOURNAL OF
TECHNO-ENGINEERING
IJTE
ISSN: 2057-5688

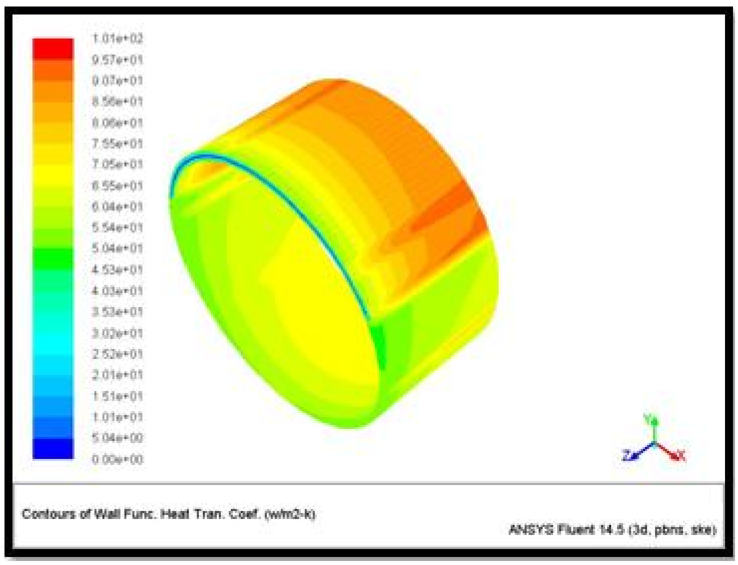


Velocity magnitude



HEAT TRANSFER COEFFICIENT

ISSN: 2057-5688



Results and observations

RESULTS TABLE

Speed- 2500rpm

Eccentricity	**Fluid**	**Pressure (Pa)**	**Velocity (m/s)**	**Heat transfer coefficient (w/m^2-k)**	**Mass flow rate (kg/s)**	**heat transfer rate (w)**	**Temperature (K)**	**Heat flux (w/mm^2)**
0.8	Air	4.29e+01	1.68e+01	3.39e+02	7.206e-07	0.2101593	100	0.024978
	helium	2.74e+01	1.34e+01	1.01e+02	4.059e-06	0.103042	100	0.07993

INTERNATIONAL JOURNAL OF TECHNO-ENGINEERING
IJTE
ISSN: 2057-5688

1.0	Air	4.93e+01	1.38e+01	9.92e+01	4.039e-06	0.200172	100	0.02454
	helium	3.34e+01	1.73e+01	3.17e+02	3.3644e-08	0.218414	100	0.04003
1.5	Air	6.75e+01	1.35e+01	9.54e+01	4.1387e-06	0.31195	100	0.0236
	helium	5.19e+01	1.68e+01	3.06e+02	1.672e-07	0.6503	100	0.071503

Speed- 5000rpm

Eccentricity	**Fluid**	**Pressure (Pa)**	**Velocity (m/s)**	**Heat transfer coefficient (w/m^2-k)**	**Mass flow rate (kg/s)**	**heat transfer rate (w)**	**Temperature (K)**	**Heat flux (w/mm^2)**
0.8	Air	1.37e+02	2.57e+01	1.66e+02	1.132e-06	0.1191	100	0.040508
	helium	5.49e+01	3.65e+01	3.39e+02	1.44e-06	0.327392	100	0.079035
1.0	Air	1.56e+02	2.76e+01	1.64e+02	1.488e-06	0.14862	100	0.040036
	helium	6.65e+01	3.72e+01	3.17e+02	1.497e-06	0.2255	100	0.07573
1.5	Air	2.09e+02	2.70e+01	1.59e+02	6.705e-08	0.0053710	100	0.038855
	helium	1.05e+0	3.36e+01	3.12e+0	2.95e	0.014746	100	0.07262

ISSN: 2057-5688

		2		2	-08			

INTERNATIONAL JOURNAL OF TECHNO-ENGINEERING
IJTE

ISSN: 2057-5688

CONCLUSION

Thermo hydrodynamic journal bearings are analyzed by using Computational fluid dynamics (CFD) and fluid solid interaction (FSI) approach on different models by varying L/D ratios and eccentricity ratios using ANSYS in order to evaluate the fluid pressures, velocity, heat transfer coefficient, mass flow rate, heat transfer rate, temperature distribution and heat flux. Journal bearings for different eccentricities are modeled in 3D modeling software Pro/Engineer. The eccentricities considered are 0.8, 1.0 and 1.5 at different fluids (air and helium).CFD analysis results, the pressure is increasing by increasing eccentricities thereby increasing the thermal flux values. Heat transfer rate values are increasing by increasing the speed by the fluid air. Mass flow rate more value at eccentricity 1.0 by the fluid air at 5000rpm. Heat transfer coefficient values are more for eccentricity 0.8 and fluid helium and thermal flux values are more for eccentricity 0.8 and fluid helium.we concluded the thermo hydrodynamic journal bearing, the suitable eccentricity is eccentricity 0.8 and increases the efficiency by using helium when compare the air.

REFERENCES

1. Elasto-thermo hydrodynamic lubrication analysis of full 360 journal bearing using CFD and FSI techniques by B. S. Shenoy, R. S. Pai, D. S. Rao, R. Pai, ISSN 1 746-7233, World Journal of Modelling and Simulation Vol. 5 (2009) No. 4, pp. 315-320
2. Analysis of Thermo hydrodynamic Journal Bearing Using CFD and FSI Technique by PriyankaTiwari, Veerendra Kumar, www.ijert.org, Volume/Issue: Vol. 3 - Issue 7 (July - 2014), e-ISSN: 2278-0181
3. JOURNAL-BEARING DESIGN AS RELATED TO MAXIMUM LOADS, SPEEDS, AND OPERATING TEMPERATURES by Samuel A. McKee, Part of Journal of Research of the National Bureau of Standards, Volume 19.,October 1937
4. Journal bearing performance and metrology issues by S. Sharma, D. Hargreaves, W. Scott, Journal of Achievements in Materials and Manufacturing Engineering
5. Analysis of a Rough Elliptic Bore Journal Bearing using Expectancy Model of Roughness Characterization by P.C. Mishra
6. P. Allaire, J. Nicholas, E. Gunter. Systems of Finite Elements for finite bearings. ASME Journal of Lubrication, Technology, 1972, (99): 187–197.