CFD ANALYSIS OF ELASTO HYDRO-DYNAMIC LUBRICATION JOURNAL BEARING USING CASTOR OIL AND BRONZE MATERIAL

Manojkumar [1], Shamburaje [2] Rameshwar[3]

[1] Professor, Department of Mechanical Engineering, SGOI COE (Belhe), Maharashtra, India,
[2] Professors Department of Mechanical Engineering, SGOI COE (Belhe), Maharashtra, India,
[3]Student Department of Mechanical Engineering, GNDEC (Bidar), Karnataka, India

ABSTRACT

Elasto-hydrodynamic journal bearing are analyzed by using the computational fluid dynamics (CFD) And fluid structural interactions (FSI) approach. In order to finding the displacement, stress and pressure profile distribution in the bearing structure by using the boundary condition. Journal bearing models are developed in PRO/E software and models are introduced in ANSYS software by taking L/d ratio as 2, 2.1, 2.2, 2.3, and 2.4. And an eccentricity is 0.8.The analysis is carried out for lubricating oil like CASTOR OIL. For the CFD analysis the oil is chosen as Castrol oil. For the structural analysis the material is chosen as bronze. Since inlet pressure of that of the CFD value has been given and displacement, stress results are calculated. For CFD it is accepted that the flow is laminar and steady. And the fluid is used for the CFD is CASTOR and by considering the boundary condition as speed as 3000 rpm. From this we are finding the pressure profile for journal bearing from this we are finding the pressure of journal bearing. The pressure profile for the CASTOR oil are found to be as 58092.16n/m^2 58212.34 n/m2 59162.67 n/m^2 59592.65 n/m^2 respectively.

Keyword: *- journal bearing1, CFD2, CSD3, ANSYS4, castor oil5, bronze6, L/D Ratio7and eccentricity.etc*

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1. INTRODUCTION

Bearing is a mechanical element that permits relative motion between two parts, such as the shaft and the housing, with a minimum friction. The function of the bearing is as follows: The bearing supports the shaft or the axle and holds it in the right position.

- The bearing supports the shaft or the axle and holds it in the correct position.
- The bearing takes up the forces that act on the shaft or the axle and transmits them to frame or the foundation.
- The bearing ensures the free rotation of the shaft or the axle with minimum friction.

1.1 CLASSIFICATION OF BEARING:

Bearings are classified in different ways. Depending upon the direction of forces that acts on them, bearing are classified into two categories:

- Radial bearing supports the load, which is perpendicular to the axis of the shaft.
- Thrust bearing supports the load, which act along the axis of the shaft.

Depending upon the type of friction, bearing are classified into two main groups:

- Sliding contact bearing.
- Rolling contact bearing.

Sliding contact bearing is also called plain contact bearing, journal bearing or sleeve bearings. In this case the surface of the shaft is slides over the surface of bush resulting in friction and wear. In order to reduce the friction, these two surfaces are separated by a film lubricating oil. The bush is made of special bearing material like white metal or bronze.

Rolling contact bearing is also called antifriction bearing or simply ball bearing. Rolling element such as balls or rollers, are introduced between the surfaces that are in relative motion. In this type of bearing sliding friction is replaced by rolling friction.

- Sliding contact bearing is used in the fallowing application:
- Crankshaft bearing in petrol and diesel engine
- Centrifugal pumps.
- Large size electric motor.
- Steam and gas turbine.

Rolling contact bearing is used as fallowing application:

- Machine tool spindle.
- Gear boxes.
- Small size electric motors.

1.2 LUBRICATION AND JOURNAL BEARING:

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

The object of the lubricant is as follows:

- Reduce the friction.
- To reduce or prevent wear.
- To carry the away heat generated due to friction.
- To protect the journal and bearing from corrosion.

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.

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

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

(b) Y-momentum equation

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

(c) Z-momentum equation

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

(iii) Energy equation:

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

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:

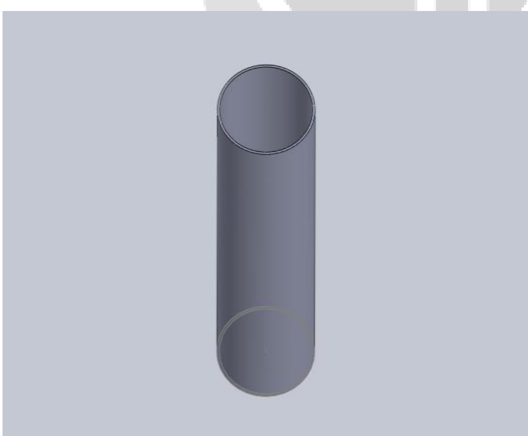
Table -1 DETAILS OF CIRCULAR JOURNAL BEARING

Journal radius	0.05 m
Radial clearance	50 μm
Bearing pad thickness	0.005 m
L/D ratio	2.0, 2.1, 2.2, 2.3,2.4
Eccentricity ratio	0.8

The geometrical models of EHL journal bearings are shown figures

1. L/D =2 AND ε =0.8

2. L/D =2.1 AND ε =0.8



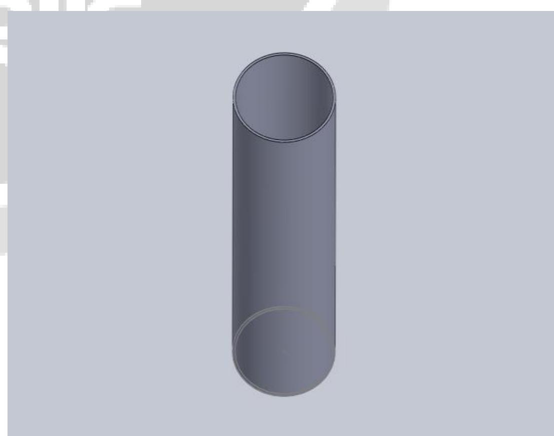
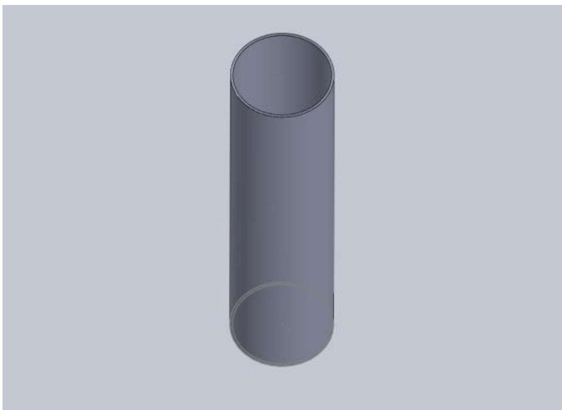


Fig -1: model of journal bearing with Length-Diameter = 2.1 and 2.2

3. L/D =2.2 AND ε =0.8



4. L/D =2.3 AND ε =0.8

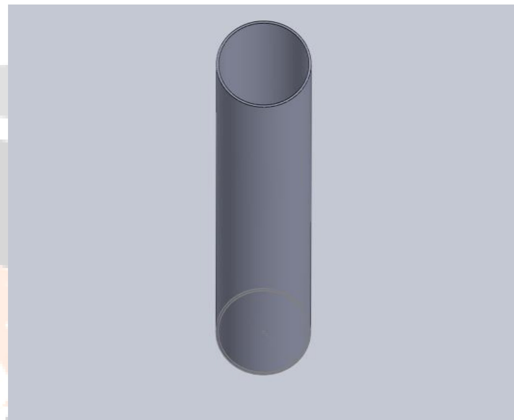


Fig -2: model of journal bearing with Length-Diameter = 2.3 and 2.4

5. L/D=2.4 AND ε =0.8

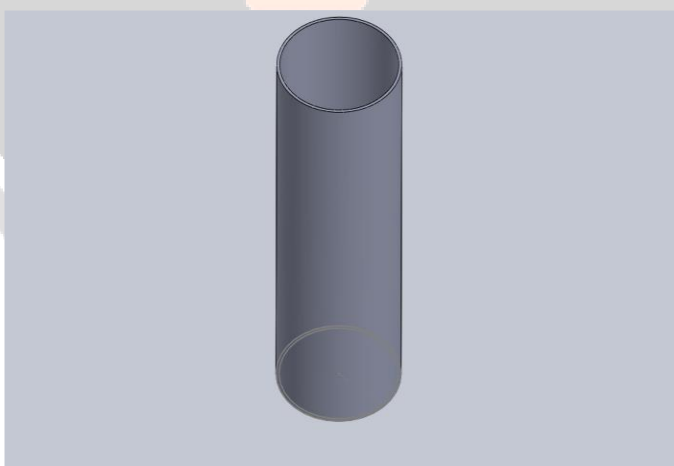


Fig -3: model of journal bearing with Length-Diameter = 2.5

2.3 LUBRICTING OILS:

The desirable properties of lubricating oil are as fallow;

- It should be available in a wide range of viscosities.
- There should be little change in viscosity of the oil with change in temperature.
- The oil should be chemically stable with the bearing material and atmosphere at all temperature encountered in the application,
- The oil should have sufficient specific heat to carry away frictional heat, without abnormal rise in temperature.
- It should be commercially available at reasonable cost

Table -2: CASTOR OIL PROPERTIES:

Density	961 kg/m^3
Specific heat	1800 j/kg k
Thermal conductivity	0.18 w/m k
Viscosity	0.2844 n-s/m^2

2.4 Problem solving steps in ANSYS 14.5 work bench.

The solution for the given fluid flow problem using ANSYS workbench is obtained by following the below mentioned 3 important steps.

1. Pre-processing.
2. Set up and solution.
3. Post processing.

STEPS OF PRE PROCESSING:

In this we considered set up conditions to obtain the solution,

Step1. Mesh:

Read the mesh file

File>read>mesh as the mesh file reading ANSYS fluent repeats progress console.

Step2 .General settings;

Step3. Check the mesh;

Step4. Models;

Step5. Material;

Step6. Cell zone condition

Step7. Boundary condition.

2.5 Structural Analysis of journal bearing.

The pressure field obtained from fluid dynamics is used in structural analysis to determine the displacement and stresses occurring in mating surfaces. Laminar steady flow is considered in fluid dynamics bronze is considered as material in structural analysis.

Commercially available ANSYS software, which is based on FEM, is used for structural analysis. ANSYS is universally useful software to solve numerically the problems of mechanical/civil engineering involving static/changing, auxiliary investigation (both straight and nonlinear), warmth exchange, and liquid issues, and additionally acoustic and electromagnetic issues.

Table -3: Bronze material properties:

Young's modulus	75000 MPa
Poisson's ratio	0.29
Density	0.0000064kg/mm^3

Imported model

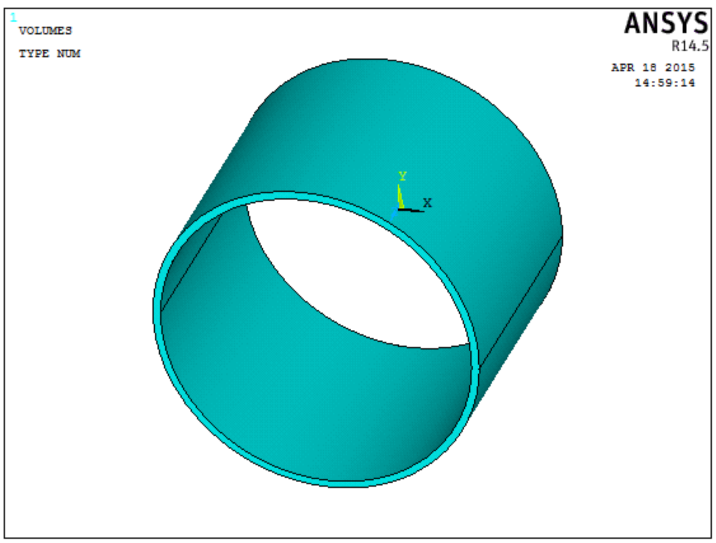


Fig -4: imported model in ANSYS software.

Meshed model

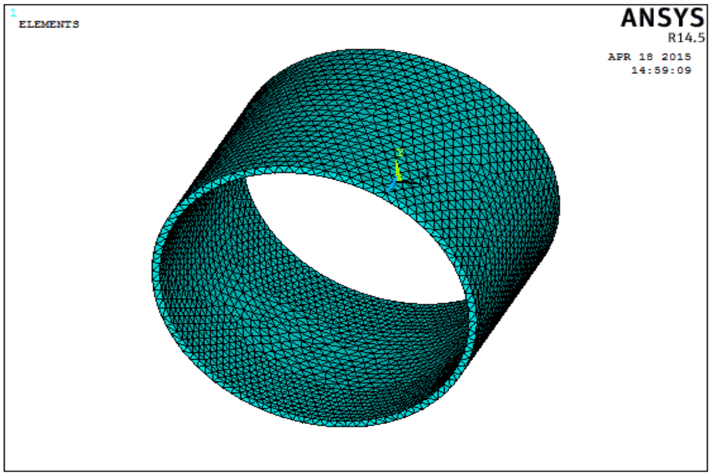


Fig -5: meshed model

Structural>pressure

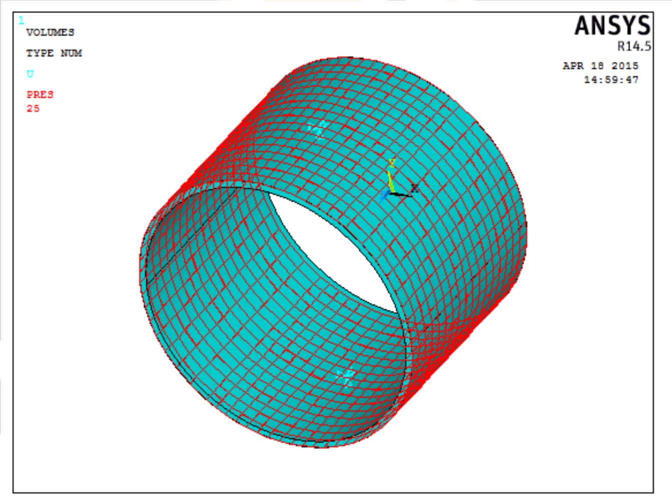


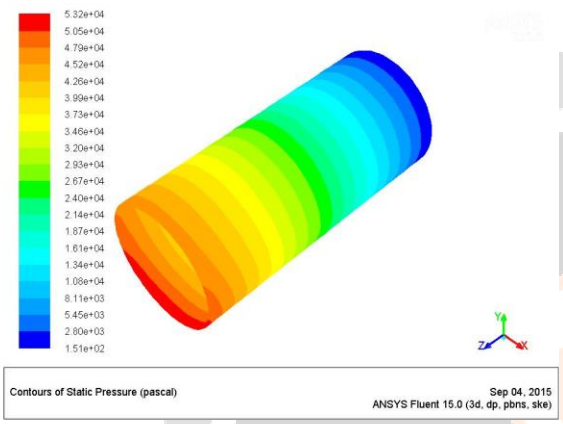
Fig -6: giving pressures to model

3. RESULTS AND DISCUSSION:

The analysis of the journal bearing is done by using the FLUENT® software and laminar flow equation is used for this model. And to which a standard k-Ɛ model is used for laminar flow. The main equations are solved for the fluid flows are the laminar modelling and momentum equation. Solution of Navier-stokes equation gives the velocity vectors and pressure in the fluid flow region. FLUENT® has the capability to solve the Navier stokes equation with standard k-Ɛ laminar model.

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 deformation and stresses occurring in mating surfaces using CASTOR oil.

1. L/D = 2.0 and ε = 0.8



2. L/D = 2.1 and ε = 0.8

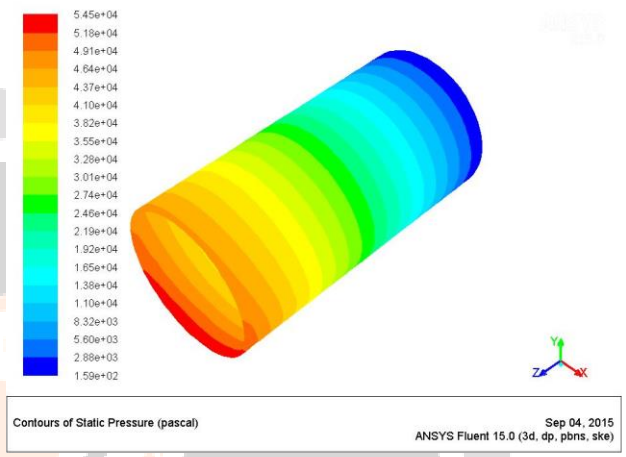
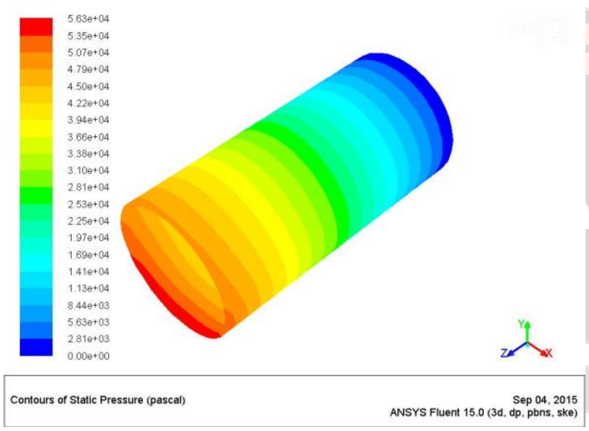


Fig -7: Pressure profile for L/D = 2.0 AND 2.1 for CASTOR oil.

3. L/D = 2.3 and ε = 0.8



4. L/D = 2.4 and ε = 0.8

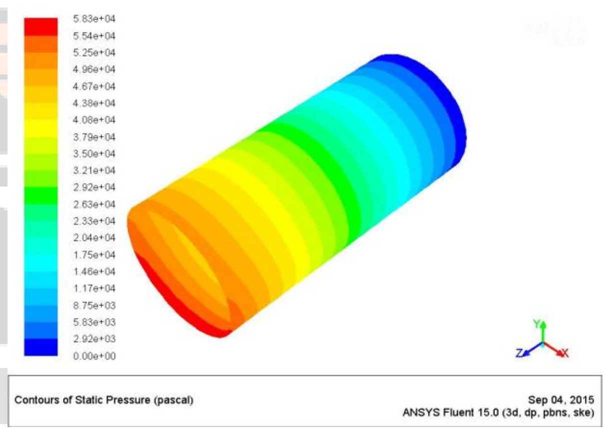


Fig -8: Pressure profile for L/D = 2.3 AND 2.4 for CASTOR oil.

5. L/D = 2.5 and ε = 0.8

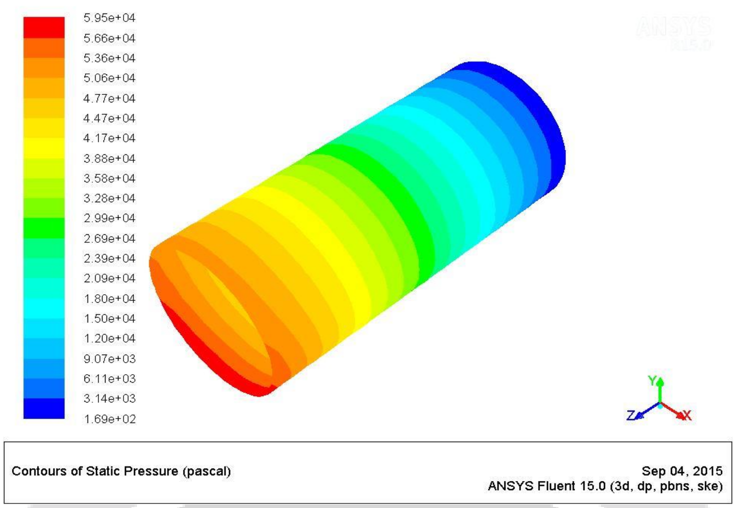


Fig -9: Pressure profile for L/D = 2.5for CASTOR oil.

3.3FSI results:

The result is obtained from fluid flow analysis through CFD are gives as input to the structural analysis problem to solve fluid structure interaction problems. The pressure values obtained from by FLUENT is utilized in the coupled field analysis and is given in input to structural analysis that has been carried out using ANSYS to get displacement and stress values in journal bearings.

The material properties considering structural analysis are listed below. The displacement and stresses are shown for BRONZE material.

1. **L/D = 2.0 and ε =0.8**

DISPLACEMENT

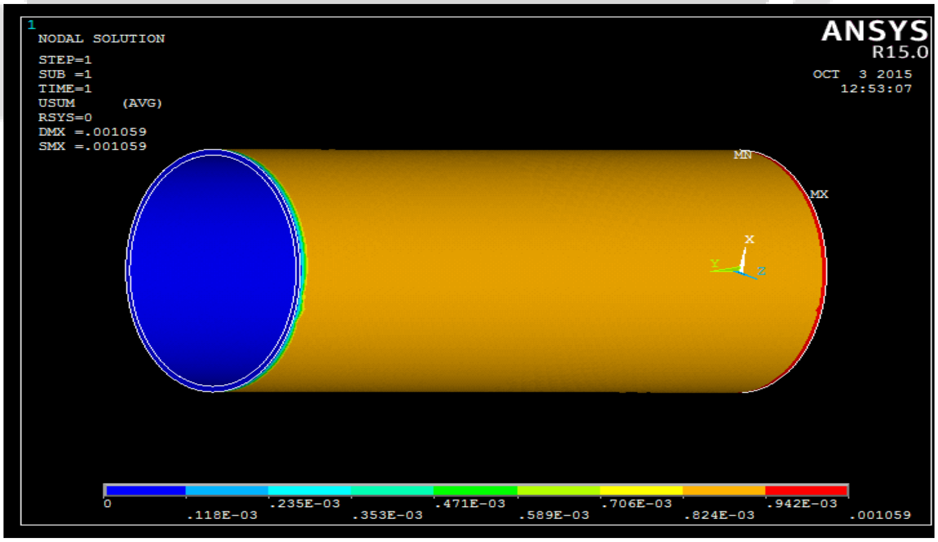


Fig -10: displacement for L/D = 2.0for BRONZE material.

STRESS

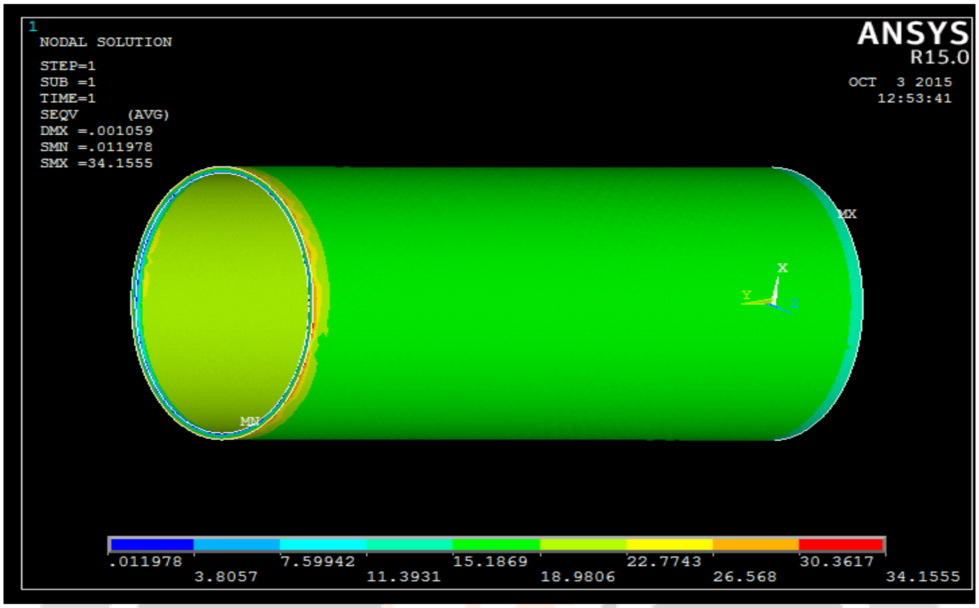


Fig -11: stress for L/D = 2.0for BRONZE material.

2. **L/D = 2.4 and ε = 0.8**

DISPLACEMENT

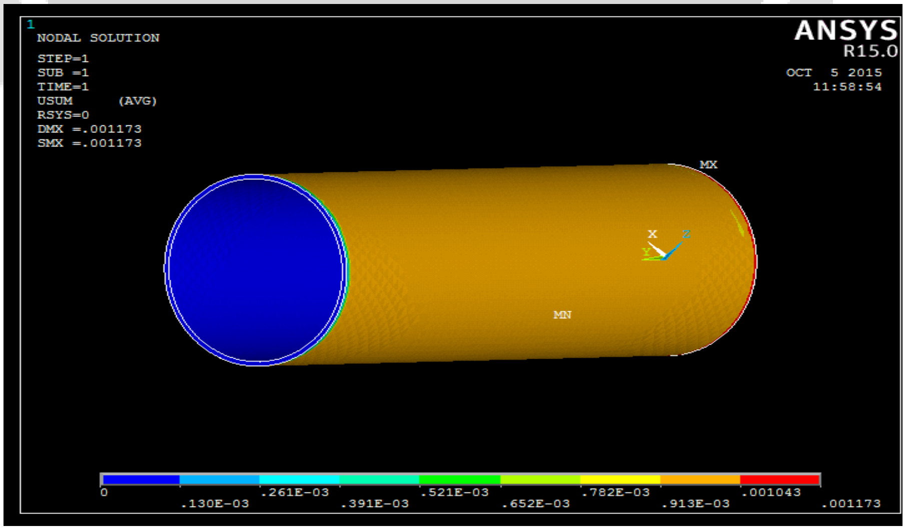


Fig -12: displacement for L/D = 2.4for BRONZE material.

STRESS

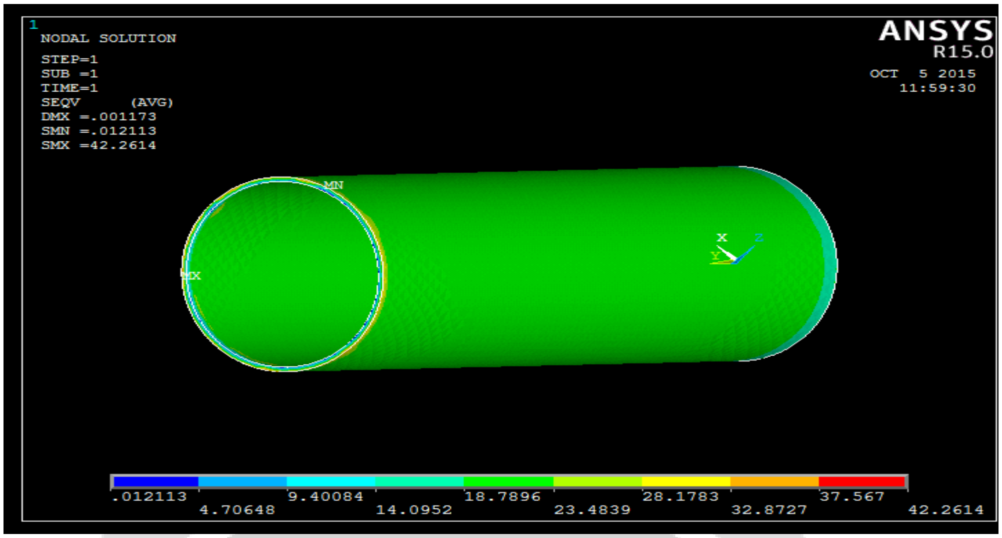
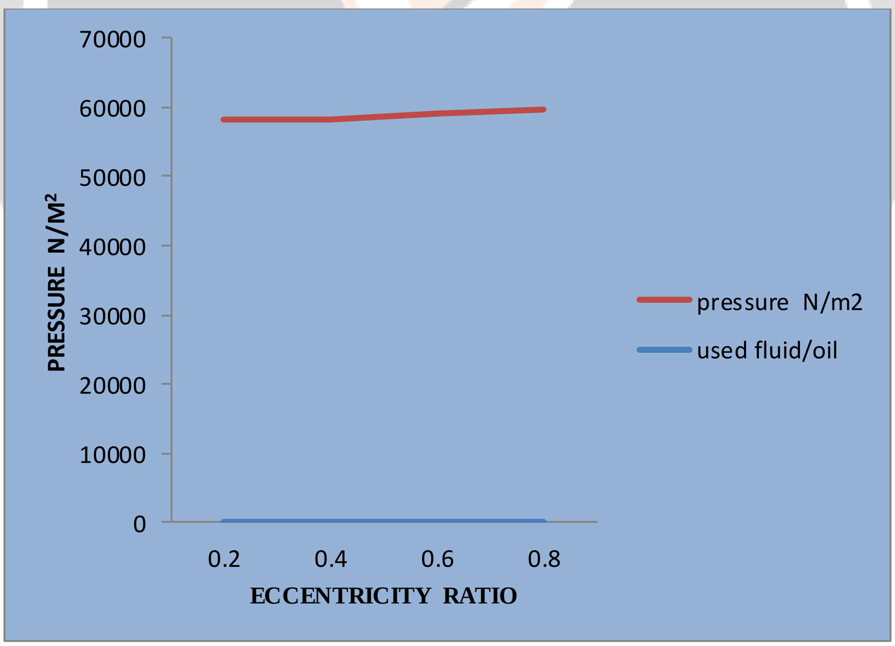


Fig -13: stress for L/D = 2.4for BRONZE material.

3.4 Graphic representation for CASTOR OIL for different L/D ratio



4. CONCLUSION:

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

The CFD and structural analysis is done on different models using ANSYS in order to evaluate the fluid pressures, Stress distribution and displacement in journal bearing. Different models of journal bearing are designed by varying L/D ratios 2.0, 2.1, 2.2, 2.3, and 2.4 and eccentricity ratios 0.8. 3D modeling is done in Pro/Engineer. CFD and structural analysis is done in ANSYS.

By observing the CFD and structural analysis results, the pressure is increasing by increasing the L/D ratios. And displacement value increases for bronze material for different L/D ratio.

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