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CFD Analysis of Fluid film liquid lubricated cylindrical journal bearing using ANSYS software

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Abstract: The Current research work uses the ANSYS software to examine the fluid structure and computational fluid dynamics of hydrostatic fluid film oil lubricated bearings. The journal bearings use different types of lubrication fluids. There are numerous types of lubrication fluids but here we take only 2 types of fluid grades SAE 20 and SAE 40. The pressure in the oil film is satisfying the Reynold's equation, which is actually a function of the film thickness. This research work uses the calculation of bearing due to loading condition by using length to diameter ratio (L/D) [3]. The eccentricity is varying from 0 to 1.0 with intervals of 0.2 and starts with 0.3 as 0.3, 0.5, 0.7, and 0.9. Here SAE 20 and SAE 40 lubricants are considered for the current analysis with the same boundary conditions and the output is compared with both the liquid lubricants. The analysis is performed with the help of ANSYS software for both CFD and Structural analysis. The output of the structural workbench is linked to the CFD Simulation to apply the pressure of the bearing [1].

Keywords: CFD Computational fluid Dynamics, SAE Society of automotive engineers, AR aspect ratio.

Introduction:

An external source of pressurized fluid drive lubricant between the two surfaces in a hydrostatic bearing, allows for non-contact operation and load support. Huge direct stiffness as well as damping coefficients are provided by hydrostatic bearings, which can handle huge loads without journal rotation. As a result, bearings are critical machine components for improving the quality of rotating machinery. The Hydrodynamic journal bearings are widely used in high-speed rotating machines such as turbines and big compressors.

In the absence of journal bearing rotation, hydrostatic bearings rely on external fluid pressurization to provide the proper load support to be needed and a high centering stiffness. The load capacity of hydrostatic bearings and the stiffness of the bearings are independent of the fluid viscosity making the components excellent for rotor supports in fluid pumps.

The journal bearings are used in cryogenic liquid turbopumps and also used in oil lubricated bearings and is currently being used with increased efficiency while reducing mechanical complexities and rotor spans. The technology allows for the fluid film bearing technology with limited number of components.

The Hydrostatic bearing with huge stability and the corresponding dynamic force is created by angling of the liquid injection. The case analysis of turbulent flow of the journal bearings is discussed and the performance characteristics of the dynamic and static force are analyzed.

Thrust and Radial fluid film bearings are shown in the below figure. A certain load capacity is derived from flow resistance effect from the feed restrictor in thin film lands, rather than flow driven from shear force effects (Surface sliding). The design of the fluid film bearings is shown in figure 1.

Figure 1 Hydrostatic radial and thrust bearings [4]

Problem Identification: In this current research we have considered 2 lubricants to actually identify the performance of the interaction of fluid film with elastic properties and the lubricant itself. In this analysis we have taken SAE 20 and SAE 40 lubricant for CFD and structure workbench with different eccentricity ratio. The hydrodynamic bearing is one of the key parts which define for specific RPM with specific parameters and a certain amount of load.

Parameters of journal bearing [2]:

Diameter of journal D	100 mm
Journal length L	50
Ratio (L/D)	0.5
Eccentricity mm e	ε x C
Radial clearance C	0.145 mm
Eccentricity ratio ε	0.3 to 0.9

Eccentricity calculation table on L/D at 0.5:

S No.	**Ɛ**	**C**	e = Ɛ×C
1	0.3	0.145	0.0435
2	0.5	0.145	0.0725
3	0.7	0.145	0.1015
4	0.9	0.145	0.1305

Analytical calculation of stress and force induced in bearing [2]

$$F = \frac{\pi^2 D^2\ L\ N}{30*C}\ \mu$$

$$\sigma = \frac{F}{A}\ \text{N/mm}^2$$

where
F = force in N
D = diameter of journal bearing in mm
L = length of bearing in m
N = speed in m/s
μ = coefficient of friction
First of all, a graphical model of the bearing is to be developed with specified parameters in geometry tools in the ANSYS Software then a series of steps to be followed to run the simulation.

1. Geometry
2. Meshing
3. Setup the program

4. Solution
5. Results

Meshing the Geometry of journal bearing

A specific geometry is made by using 2-dimensional sketches of its inner ring around the centre of the journal bearing. A thin layer of the oil film hence created to define the proper geometry of the bearing. After complete modelling of the structure, it is required to mesh the structure and divide the whole geometry into small nodes.

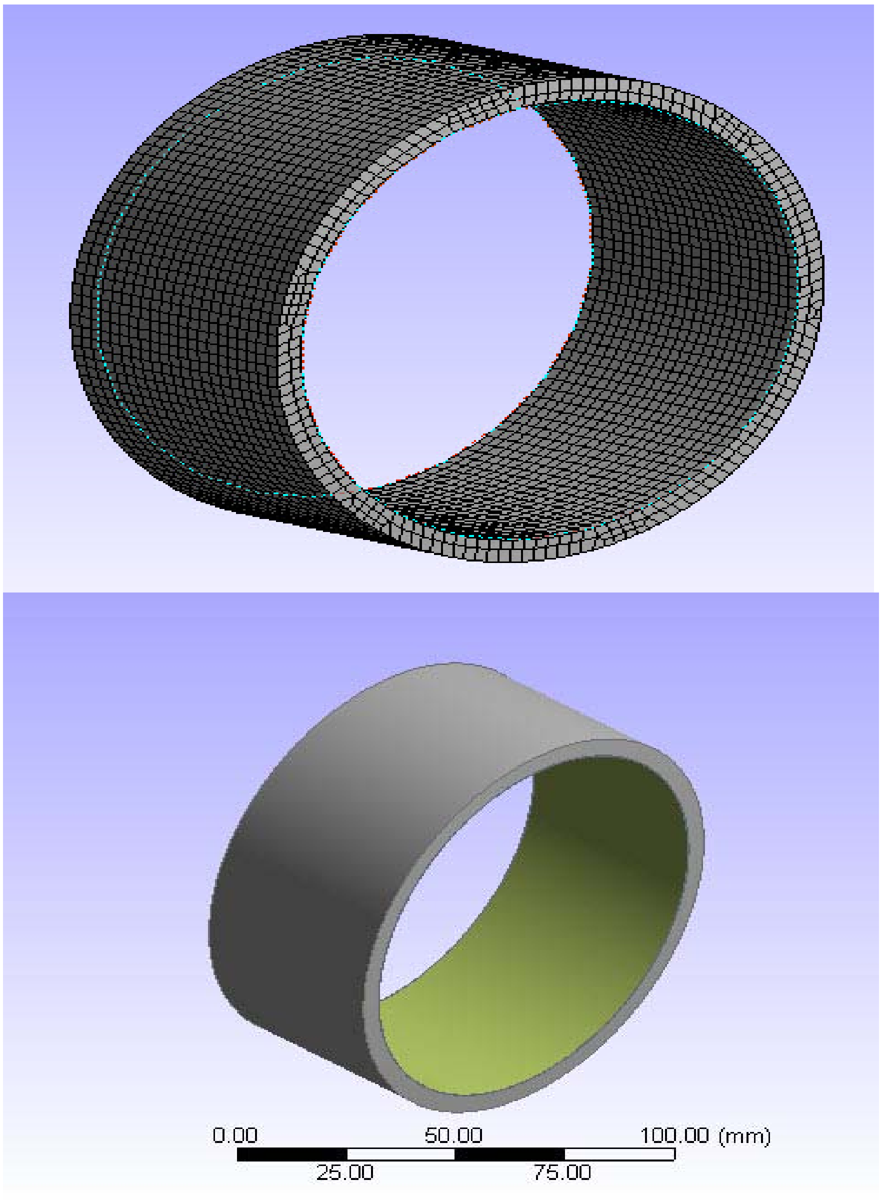

Figure 2: Meshing of the journal bearing

Boundary Conditions and the setup of the analysis

The geometrical structure of the journal bearing is based on outlet and inlet is for identification of the flow of liquid, a solver is used to simulate the analysis. The overall analysis is done on a thin film surface of the liquid.

Property of fluid film [1]

PROPERTIES	SAE20	SAE40	BABBIT MATERIAL
Density (kg/m3)	872	887	0.000007272
Thermal conductivity (w/m-k)	0.136	0.136	Young's modulus
Specific heat Cp(J/kg-k)	19252.96	1800	50,000MPa
Viscosity (kg/m-s)	0.0056	0.0056	Poisson's ratio
Velocity of flow (m/s)	10.45	10.45	0.35

Result and Solution of the analysis

Under certain loading conditions we observe the following results in graphical form

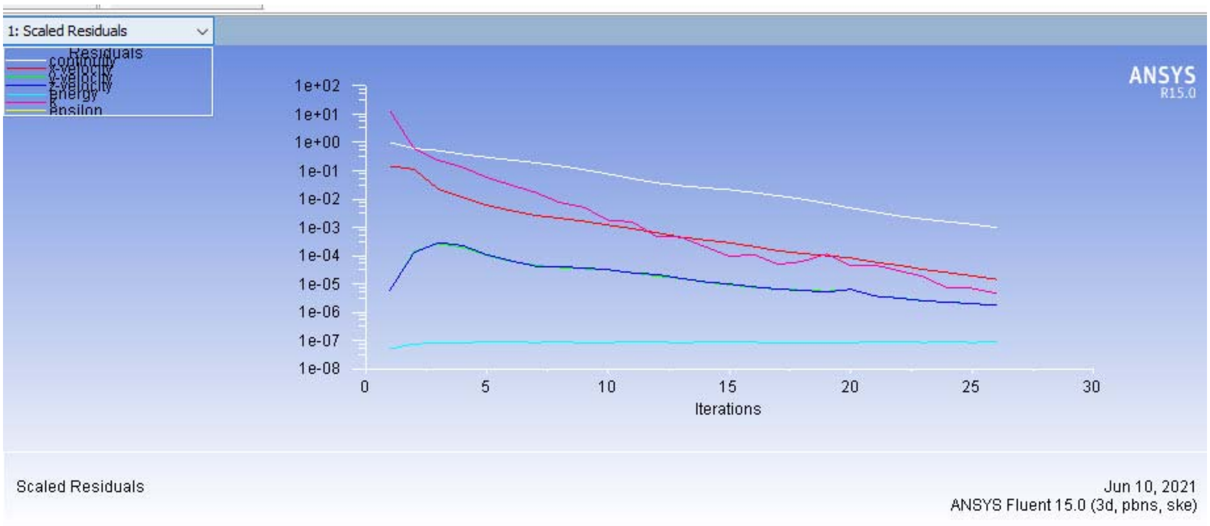

Figure 3: Iterations of the loading conditions

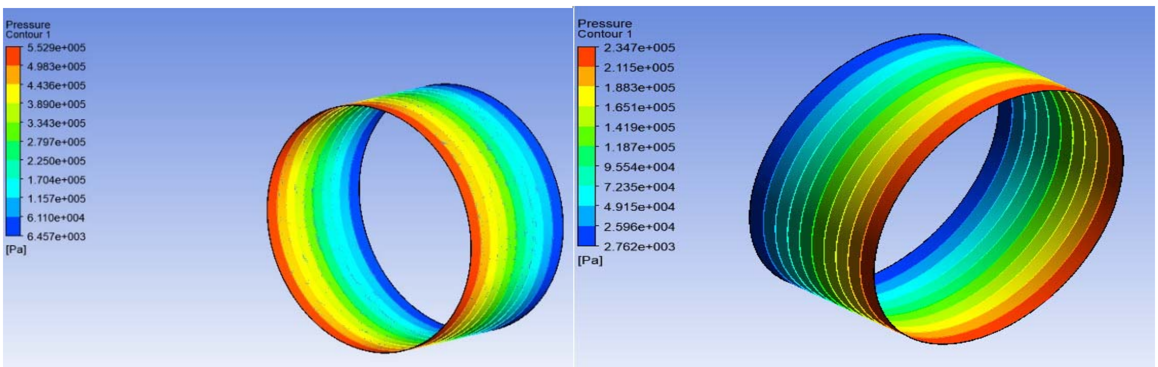

Figure 4: The CFD result is hyperlink with structure analysis workbench to apply the required pressure in the bearing.

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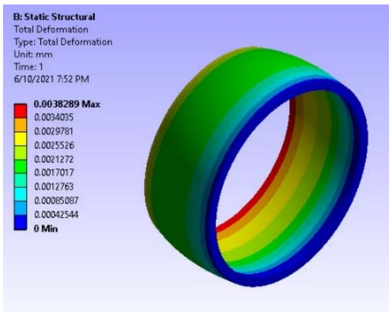


Figure 5: Total deformation

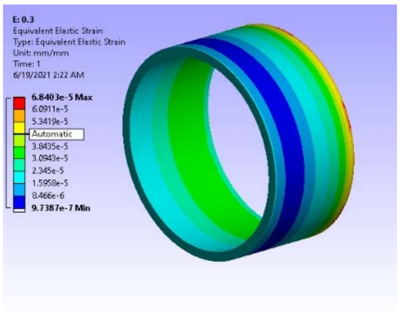


Figure 6: Elastic strain

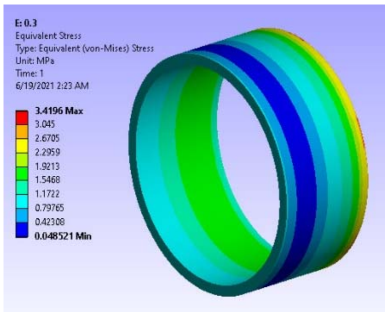
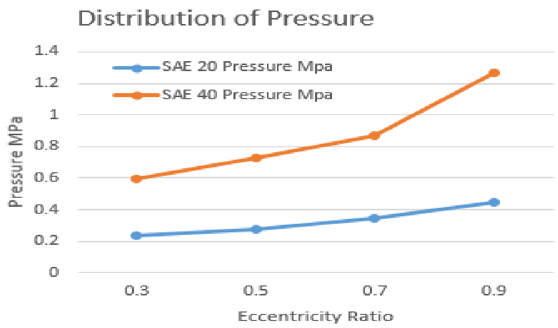
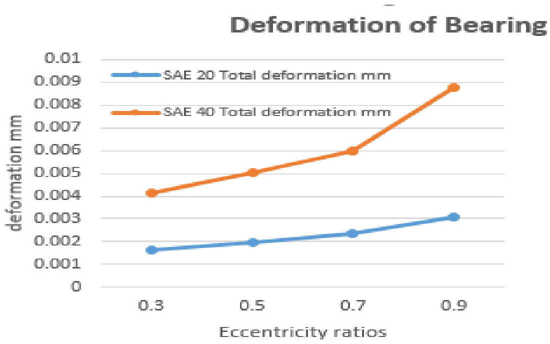
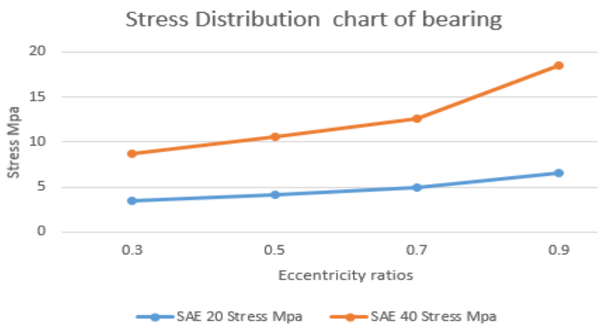


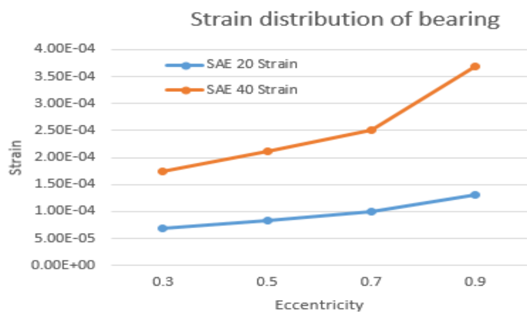
Figure 7: Stress distribution

Result of SAE 20 and SAE 40 fluid film [2]









The distribution of strain of bearing and stress pressure deformation is given to identify the nature of oil film and bearing under the loading conditions we have taken.

Conclusion

Based on the above result and solution data in the result and solution section we can conclude that the nature of the graphical result for all cases is almost similar and minute variations have found for eccentricity ratio of 0.9. As seen from the result the bearing has a significant amount of visual distortion it shows that some different nature is higher as compared to other eccentricity ratios, so that we might say that value of stress, strain and other parameters are increasing at a steady rate and is maximum at eccentricity ratio 0.9. when the data is compared SAE 20 oil with 0.3 eccentricity ratio is better choice for the fluid film bearings.

References:

[1] Debaprava Das and Dr. Ritesh Kumar Dewangan, CFD Analysis of Fluid Film of Liquid Lubricated Cylindrical Journal Bearing.IJAER,2021, Vol 16, No.7.

[2] Debaprava Das and Ritesh Kumar Dewangan, A Brief Analysisof Fluid film liquid lubricated cylindrical journal bearing, IOSR Journal of engineering (IOSRJEN), Vol 11, issue 10, October 2021.

[3] K Prasad et al, "Fluid Structure Interaction of Liquid Lubricated Cylindrical Journal Bearing using CFD", IJIRSET, Vol.5, issue 3, march 2016.

[4] MahenderJanagam, D. Prasuna Lilly Florence and Dr. P. H V SeshaTalpaSai, Fluid Structure Interaction On Journal Bearings At Different L/D And Eccentricity Ratios, International Journal of Science, Engineering and Technology Research (IJSETR), Volume 4, Issue 11, November 2015.

[5] 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,World Journal of Modelling and Simulations 1 746-7233, Vol. 5 (2009) No. 4, pp. 315-320.

[6] Priyanka Tiwari, Veerendra Kumar, Analysis of Hydrodynamic Journal Bearing Using CFD and FSI Technique, www.ijert.org, Volume/Issue: Vol. 3 - Issue 7 (July - 2014), e-ISSN: 2278-0181.
[7] Samuel A. McKee, Journal-Bearing Design as Related to Maximum Loads, Speeds, And Operating Temperatures, Part of Journal of Research of the National Bureau of Standards, Volume 19, October 1937.
[8] S. Sharma, D. Hargreaves, W. Scott, Journal bearing performance and metrology issues, Journal of Achievements in Materials and Manufacturing Engineering
[9] P. Allaire, J. Nicholas, E. Gunter. Systems of Finite Elements for finite bearings. ASME Journal of Lubrication, Technology, 1972, (99): 187–197.
[10] P. Allaire, J. Nicholas, E. Gunter. Systems of Finite Elements for finite bearings. ASME Journal of Lubrication Technology, 1972, (99): 187–197.
[11] Proc. of ASME/STLE International Joint Tribology Conference, San Diego, California, US, 2007, 1–3. IJTC'07, IJTC44479.
[12] J. Booker, K. Huebner. Application of Finite Element Methods to Lubrication: an Engineering Approach. ASME Journal of Lubrication Technology, 1972, (94): 313–323.
[13] Z. Guo, H. Toshio, R. Gordon. Application of CFD Analysis for Rotating Machinery Part1: zy urodynamic, Hydrostatic Bearings and Squeeze Film Damper. Journal of Engineering for Gas Turbines and Power, 2005, 127(2): 445–451.
[14] M. Reddi. Finite-Element Solution of the Incompressible Lubrication Problem. ASME Journal of Lubrication Technology, 1969,91(3): 524–533.