International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 05 Issue: 07 | July 2018 www.irjet.net p-ISSN: 2395-0072

# Experimental and Finite Element Analysis of Hydrodynamic Journal Bearing To Establish the Relation between Coefficient Of Friction and Sommerfeld Number

**Tayade Vishwaraj Supadu[1], Prof. N.S. Navagale [2], Prof.P.N.Patil[3]**

[1]*Post Graduate Student, Department Of Mechanical Engineering, SGDCOE Jalgaon*
[2,3]*Associate Professor, Department Of Mechanical Engineering, SGDCOE Jalgaon*

---***---

**Abstract -** *Hydrodynamic journal bearing is used in machineries which are rotating at high speeds and heavy loads for work done. This result in temperature rise in the lubricant film which significantly affects the performance of bearing. In order to obtain the optimized performance of hydrodynamic journal bearing experimental and FEA analysis has carried out. For this Project, journal bearing with trapezoidal was developed at variable speed and load to determine fluid behavior.By applying trapezoidal fins on external surface of hydrodynamic journal bearing improved performance of hydrodynamic journal bearing is studied by considering coefficient of friction and sommerfeld number for variable load and speed. Also we have tried to establish the relation between coefficient of friction and Sommerfeld Number by plotting graphs at variable load conditions. We also studied the experimental results for with fin and without fin on the external surface of hydrodynamic journal bearing In this Project thermo-hydrodynamic analysis of journal bearing has been simulated by using CFD technique and tried to validate the experimental results using CFD analysis for journal bearing to predict bearing performance parameter such as pressure, viscosity, Sommerfeld Number, coefficient of friction and temperature of lubricant along the bearing and we have shown the behavior of these performance parameters at various load by plotting graphs.*

***Key Words*: *Jounal Bearing, Lubrication, Coefficient of Friction, Sommerfeld Number, Speed***

## 1.INTRODUCTION

A bearing is a machine element that constrains relative motion to only the desired motion, and reduces friction between moving parts. The design of the bearing may for example, provide for free linear movement of the moving part or for free rotation around a fixed axis; or, it may prevent a motion by controlling the vectors of normal forces that bear on the moving parts. Most bearings facilitate the desired motion by minimizing friction. Bearings are classified broadly according to the type of operation, the motions allowed, or to the directions of the loads (forces) applied to the parts. Rotary bearings hold rotating components such as shafts or axles within mechanical systems, and transfer axial and radial loads from the source of the load to the structure supporting it. The simplest form of bearing, the plain bearing, consists of a shaft rotating in a hole. Lubrication is often used to reduce friction. In the ball bearing and roller bearing, to prevent sliding friction, rolling elements such as rollers or balls with a circular cross-section are located between the races or journals of the bearing assembly. A wide variety of bearing designs exists to allow the demands of the application to be correctly met for maximum efficiency, reliability, durability and performance.

Journal bearings are used to carry radial loads, for example, to support a rotating shaft. A simple journal bearing consists of two rigid cylinders. The outer cylinder (bearing) wraps the inner rotating journal (shaft). Normally, the position of the journal center is eccentric with the bearing center. A lubricant fills the small annular gap or clearance between the journal and the bearing. The amount of eccentricity of the journal is related to the pressure that will be generated in the bearing to balance the radial load. The lubricant is supplied through a hole or a groove and may or may not extend all around the journal. Under normal operating conditions, the gases dissolved in the lubricant cause cavitation in the diverging clearance between the journal and the bearing. This happens because the pressure in the lubricant drops below the saturation pressure for the release of dissolved gases. The saturation pressure is normally similar to the ambient pressure. The following model does not account for capitations and therefore predicts sub-ambient pressures. Such sub-ambient pressures are the result of the so-called Sommerfeld boundary condition. For practical purposes, these sub-ambient pressures should be neglected. Future versions of the Lubrication Shell physics interface will offer additional tools for modeling cavitation.

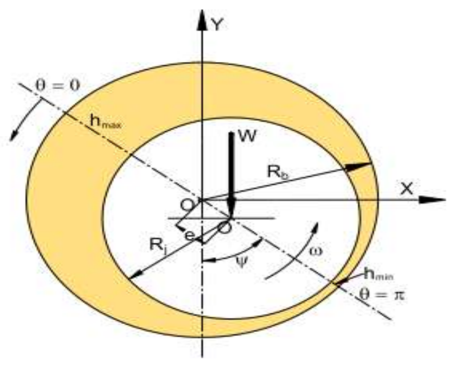


**Fig.1-** Journal Bearing

## 2. OBJECTIVES

1] To determine the Hydrodynamic pressure, viscosity and temperature of hydrodynamic journal bearing with trapezoidal fins applied on outer surface journal bearing

2] To compare the result of hydrodynamic journal bearing with fins applied on external surface

3] To validate result of experiment using analysis software

( ANSYS 14.5)

4] Determination of Sommerfeld number.

5] To establish the relationship between Sommerfeld number & coefficient of friction by plotting graph.

## 3. EXPERIMENTATION

**Fig-2 :** Journal Bearing Setup (Experimental Setup)

**Coefficient of friction is given by formula,**

$$f = 2\pi^2 \left(\frac{\mu n}{p}\right)\left(\frac{r}{c}\right)$$

Where,

f = Coefficient of Friction

μ = Dynamic Viscosity (mpa.s)

n = Speed in rps

r= radius of journal bearing (m)

c= clearance (m)

P= Load per unit area (N/m$^2$)

**Sommerfeld number is given by equation,**

**S =** ( μn/ p)*(r/c)$^2$

Where,

μ = Dynamic Viscosity (mpa.s)

n = Speed in rps

r = radius of journal bearing (m)

c = clearance (m)

P = Load per unit area (N/m$^2$)

**Table -1:** Coefficient of friction

| Bearing without fins | | Bearing with Fins | |
|---|---|---|---|
| **Initial Coefficient of Friction** | **Final Coefficient of Friction** | **Initial Coefficient of Friction** | **Final Coefficient of Friction** |
| 0.08180754 | 0.01606934 | 0.081808 | 0.018991 |
| 0.03451256 | 0.00897326 | 0.034513 | 0.010354 |
| 0.02522399 | 0.00540514 | 0.025224 | 0.006306 |
| 0.01661716 | 0.00345637 | 0.016617 | 0.004786 |
| 0.01329373 | 0.00292462 | 0.013294 | 0.003456 |

**Table-2 :** Sommerfeld Number

| Bearing without fins | | Bearing with Fins | |
|---|---|---|---|
| **Initial Sommerfeld No** | **Final Sommerfeld No** | **Initial Sommerfeld No** | **Final Sommerfeld No** |
| 0.074675229 | 0.014668349 | 0.07467523 | 0.017335321 |
| 0.031503612 | 0.008190939 | 0.03150361 | 0.009451084 |
| 0.023024862 | 0.004933899 | 0.02302486 | 0.005756216 |
| 0.015168406 | 0.003155028 | 0.01516841 | 0.004368501 |
| 0.012134725 | 0.002669639 | 0.01213472 | 0.003155028 |

The above values are obtained at variable speed of 1000rpm, 945 rpm, 925 prm,910 rpm,910rpm at the respective load of 1kg,2kg,3kg,4kg,5kg. CFD analysis is also carried out to find the viscosity for obtaining Sommerfeld Number and Coefficient Of Friction

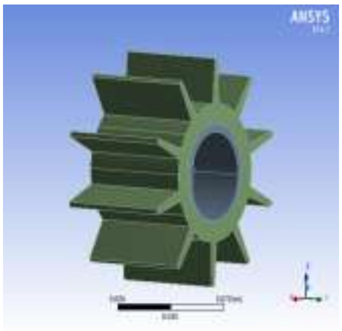


**Fig -3 :** CAD Model Of Bearing

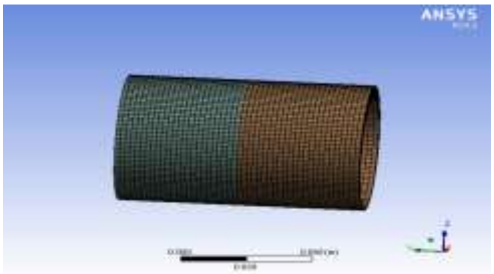


**Fig-4 :** Meshing Of Fluid Zone Model

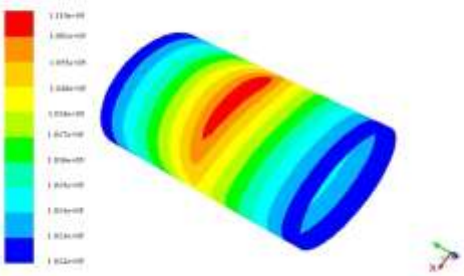

**Fig 5 :** Pressure Distribution Of Model

**Table-.3 :** Initial Experimental and CFD values

| Load | Initial Coefficient Of Friction For Bearing With Fin | | Initial Sommerfeld Number For Bearing With Fin | |
|---|---|---|---|---|
| | Experimental Values | CFD Values | Experimental Values | CFD Values |
| 1 | 0.08181 | 0.08473 | 0.074672 | 0.0773422 |
| 2 | 0.03451 | 0.04418 | 0.0315036 | 0.0403246 |
| 3 | 0.02522 | 0.02838 | 0.0230249 | 0.025903 |
| 4 | 0.01662 | 0.02127 | 0.0151684 | 0.0194156 |
| 5 | 0.01329 | 0.01329 | 0.0121347 | 0.0121347 |

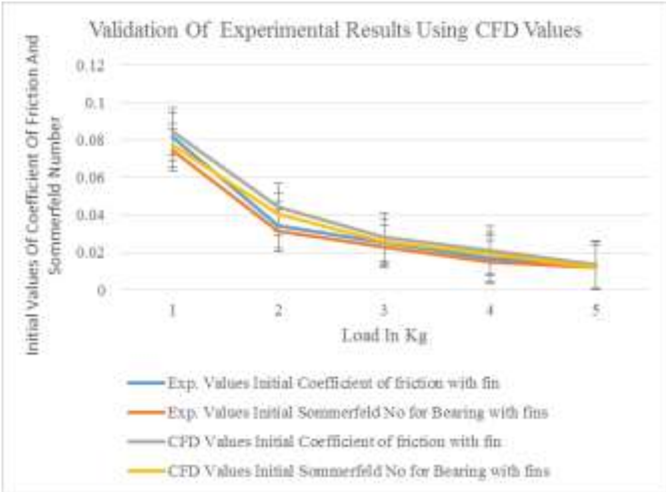


**Chart -1 :** Validation of results using CFD for initial condition

**Table -4 :** final Experimental and CFD values

| Load | Final Coefficient Of Friction For Bearing With Fin | | Final Sommerfeld Number For Bearing With Fin | |
|---|---|---|---|---|
| | Experimental Values | CFD Values | Experimental Values | CFD Values |
| 1 | 0.01899 | 0.01987 | 0.017335 | 0.0181354 |
| 2 | 0.01035 | 0.01049 | 0.009451 | 0.009577 |
| 3 | 0.00631 | 0.00658 | 0.005756 | 0.0060029 |
| 4 | 0.00479 | 0.00495 | 0.004369 | 0.004520185 |
| 5 | 0.00346 | 0.00362 | 0.003155 | 0.003301 |

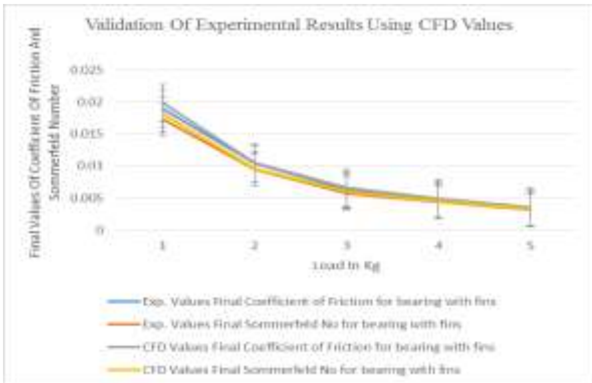


**Chart -2:** Validation of results using CFD for Final condition

## 4. CONCLUSIONS

The objective of this paper is to establish the coefficient of friction and Sommerfeld number for hydrodynamic journal bearing. For that we selected the bearing and took trial for the bearing with fin on external surface and bearing without fin. It is found that when the load is provided on the bearing (without fin) viscosity of oil is decreased with increase in temperature and when the load is applied to bearing (with fin) the temperature is decreased & correspondingly viscosity is improved. From the plot of coefficient of friction Vs load it is observed that the coefficient of friction goes on decreasing to a certain value with increase in load on bearing which indicates that the coefficient of friction is the limit zone while designing bearing parameters. From the plot of Sommerfeld number Vs load it is observed that there is decrease in Sommerfeld number value with increase in load thus it is concluded that Sommerfeld Number also controls the design of bearing and it is dependent on the operating parameters like viscosity of lubricant , speed, temperature. Also it is observed that as the value of Sommerfeld number decreases there is iproportional decrease in the value of coefficient of friction. So it becomes important to consider the value of coefficient of friction and Sommerfeld number for design of bearing to operate at optimized designed conditions and providing fin on the external surface of bearing has increased values of Sommerfeld number due to improved viscosity as compared with without fin bearing. Using CFD analysis we tried to validate the experimental results and it is found that the values of Sommerfeld Number and Coefficient of friction goes on decreasing with increase in load. Since the experimental and CFD values are having minor difference, this clears the validation of our experimental results by using CFD technique under various load conditions.

## ACKNOWLEDGEMENT

I thanks from bottom of my heart to **PROF. R.Y. PATIL**, Head of Department, SGDCOE Jalgaon.Who has been a great source of moral and timely support for completing this Paper. I would also like to thank our Principal **Dr. A.J. PATIL** for his warm support.

## REFERENCES

1] B. SomeswaraRao "The Analysis of Fluid Film Journal Bearing By Using CFD Analysis" International journal &Magazine of Engineering, Technology , Management and Research.ISSN No. 2348-4845

2] Verma A and Samant SS "Inspection of Hydrodynamic Lubrication in Infinitely Long Journal Bearing with Oscillating Journal Velocity" Journal of Applied Mechanical Engineering ISSN:2168-9873 JAME Volume 5 • Issue 3 •

3] Pantelis G. Nikolakopoulos and Dimitrios A. Bompos "Experimental Measurements of Journal Bearing Friction Using Mineral, Synthetic, and Bio-Based Lubricants" Lubricants 2015, 3, ISSN 2075-4442

4]Amit Chauhan, AmitSingla, Narender Panwar 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

5] 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

6] S Kango , R.K.Sharma R.K.Pandey "Thermal analysis of micro texured journal bearing using non-Newtons rheology of lubricant and JFO boundary condition" tribology international 69(2014) 19-29

7] MarcinFrycz, Paweł Anioł "Temperature Distribution in the Gap of slide journal Bearing Lubricated with Ferrofluids for Different Concentration of Magnetic Particles", ZeszytyNaukoweAkademiimorskiejwgdyni , nr 81, listopad 2013