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Thermal Analysis of Journal Bearing Using CFD Software for Performance Enhancement

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***Abstract-** Hydrodynamic journal bearings are used in machineries which are rotating at high speeds and heavy loads for work done. This results in increase temperature rise in the lubricant film which significantly affects of the bearing. Thermo-hydrodynamic analysis should be carried out in order to obtain the realistic performance parameters of journal bearing. Journal bearing models are developed for different speeds and eccentricity ratios to study the interaction between the fluid and elastic behavior of the bearing. Thermo-hydrodynamic analysis of circular journal bearing has been simulated by using Computational Fluid Dynamics approach. This approach solves the three dimensional Navier-stokes equation to predict the bearing performance parameters such as the pressure and temperature of the lubricant along the profile of the bearing. The CFD technique has been applied through ANSYS Fluent software. The oil flow is assumed to be laminar and the steady state condition has been assumed in the current work. The effect of variation of pressure and temperature are considered during the study. Journal bearing models are developed for different speeds and eccentricity ratios to study the interaction between the fluid and elastic behavior of the bearing. By applied the fins on journal bearing we improved the efficiency of journal bearing.*

***Keywords:** Computational Fluid Dynamics, Circular journal bearing, Thermo-hydrodynamic.*

I. INTRODUCTION

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.

Circular Journal Bearing profile is the most commonly used to support the rotating shaft extensively in high speed machinery example turbines, electric motors etc.These bearing support the external load and the presence of thick film of lubricant between the clearance spaces avoid the metal contact of rotating part of machinery with the surface of bearing. High speed of rotation causes the considerable rise in the temperature of the lubricant which significantly affects the performance of the bearing. Therefore the investigation of bearing performance based on a thermo hydrodynamic (THD) analysis requires simultaneous solution of the complex equations of flow of lubricant, the energy equation for the lubricant flow and the heat conduction equations in the bearing and the shaft. Previously, the researchers investigate the performance of the lubricant by solving the Reynolds Equation through Finite Difference Method approach. With the progress of computer technology many researchers uses commercial computational fluid dynamics (CFD) software to solve these complex equation. CFD codes provides a solution to flow problems by solving the full Navier-Stokes equations instead of Reynold's Equation. Also, CFD software solve the three dimensional energy equation to predict the temperature distribution in the fluid film where most of the researchers does THD analysis by solving the two dimensional energy equation for finding the temperature variation in the lubricant and two dimensional Reynolds Equation for pressure.

II. THERMAL ANALYSIS

2.1 Analysis of Journal Bearing

The geometry and the co-ordinate system of the journal bearing is shown in fig 1. The journal rotates with a angular velocity. The journal remains in equilibrium position under the action of external load, W and developed hydrodynamic pressure. The journal centre O is eccentric to the bearing centre O'. The film thickness h(θ) varies from its maximum value hmax at bearing angle θ = 0 to its minimum value, hmin at θ = 180. The film thickness of an aligned bearing can be expressed by [3]:

$$h(\theta) = C + e\,Cos\theta = C(1 + \epsilon\,Cos\theta)$$

Where, C and ε represent the radial clearance, eccentricity ratio of the journal bearing, θ coordinate in the circumferential direction, being measured from the maximum film thickness.

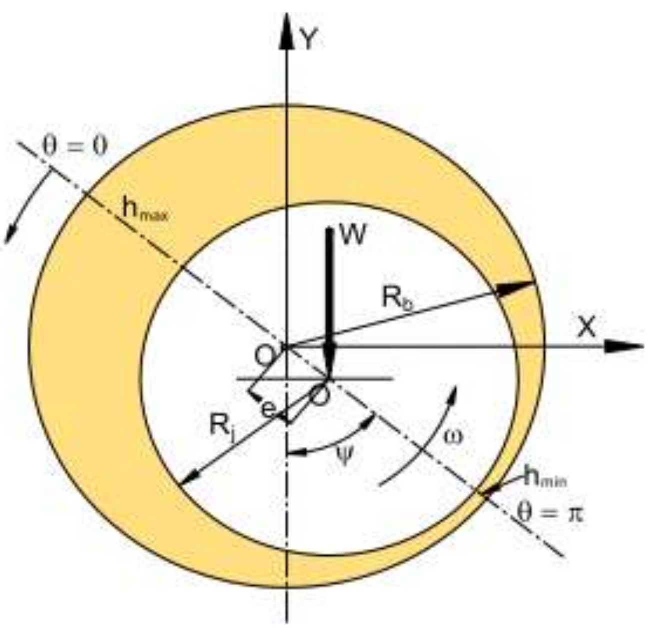

Fig. 1: schematic diagram of circular journal bearing

2.2 Computational Procedure

The Navier-Stokes equations and mass and momentum energy conservation equations are solved in steady state taking gravity forces into account. In the current work, results are obtained by assuming flow to be laminar. The bearing shell is modeled as a stationary wall. The journal is modeled as a moving wall with an absolute rotational speed of 1000 rpm. Rotational axis origin is set to the value of eccentricity. The lubricant inlets are modeled as pressure inlets and the two sides of the clearance are modeled as pressure outlets. A user defined function is used for incorporating the effect of pressure and temperature on the viscosity for thermo-hydrodynamic analysis. The segregated solver is chosen for the present numerical analysis. The velocity pressure coupling is treated using the SIMPLE Algorithm and the first order upwind scheme is used for momentum and energy.

2.3 Specification of Journal Bearing

Sr.No	Specification	Dimention
1	Diameter of Journal	50 mm
2	Diameter of Bearing (With 16 radial tapping)	55 mm
3	Bearing width	70 mm
4	Weight Set	1kg,2kg,3kg,4kg,5kg
5	Motor DC	0.5HP, 1500rpm, variable speed
6	Manometer board with 16 tubes with suitable scales and adjustable oil tank.	
7	Length of rectangular fin	70 mm
8	Width of rectangular fin	25 mm
9	Thickness of fins	4 mm

2.4 Geometrical Model

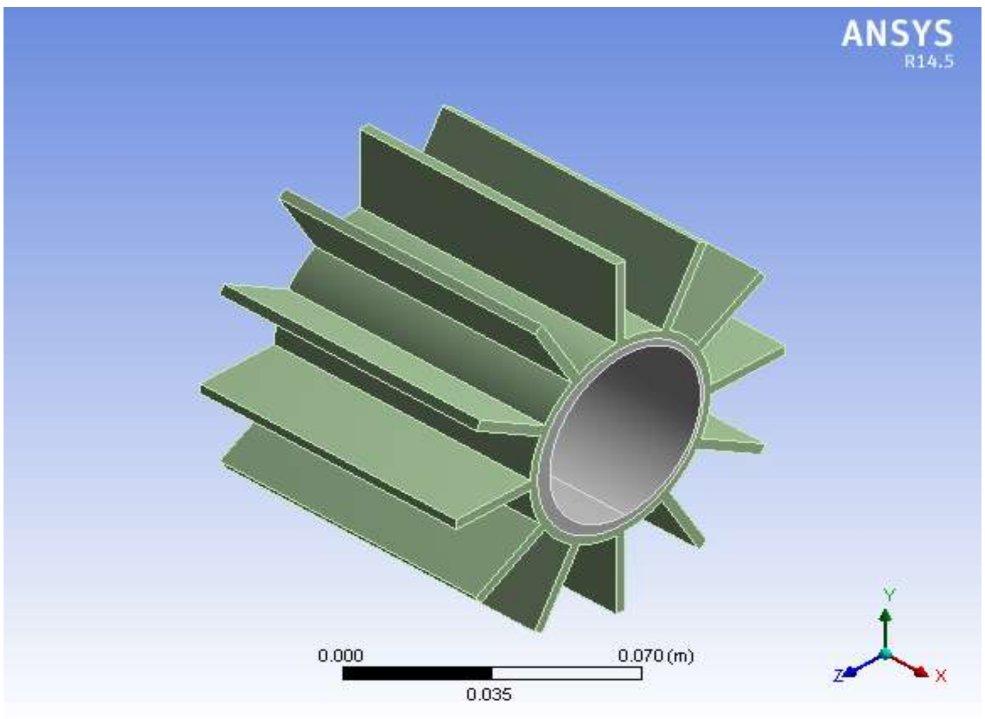

Fig. 2: Geometry model of journal bearing with fins

2.5 With fins analysis of journal bearing with applied load 1 kg

Table 1 Pressure analysis with fins &without fins

Tube No.	Pressure in Pa without fins	CFD Pressure Pa without fins	Pressure in Pa with fins	CFD Pressure Pa with fins
1	108861.4	108550	108503.5	112843.6
2	107713.8	107500	107307	109453.2
3	106711.8	106450	106328.2	102075
4	105872.6	106450	105458	101345.2
5	105093.2	106450	104696.7	101699.1
6	104108.3	105500	103717.8	100584.3
7	103251.9	104500	102847.7	101363.7
8	102378.4	102500	101977.6	100253
9	102181.4	103500	101760.1	98249.34
10	101967.3	100505	101542.5	99359.36
11	106737.5	106500	106328.2	101362.6
12	109589.4	108550	109199.5	104067.2
A	105350.1	102500	104921.9	102298.9
B	105692.7	105500	105093.2	103306.6
C	105752.7	104500	105153.2	103155.3
D	105521.4	102500	104836.3	102215.4

2.6 Viscosity and Temperature parameter of oil

Table 2 Viscosity and Temperture with fins and without fins

	Without Fins	With Fins
Oil viscosity	60.49	74.55
Temp of oil	45	40

2.7 Bearing temperature of parameter

Table 3 bearing temperture with fins

Bearing Temperture With Fins		
	Initial	Final
T1	26	38
T2	25	34
T3	25	35
T4	25	36
T5	17	17
T6	17	17

III. CFD result of journal 1 kg

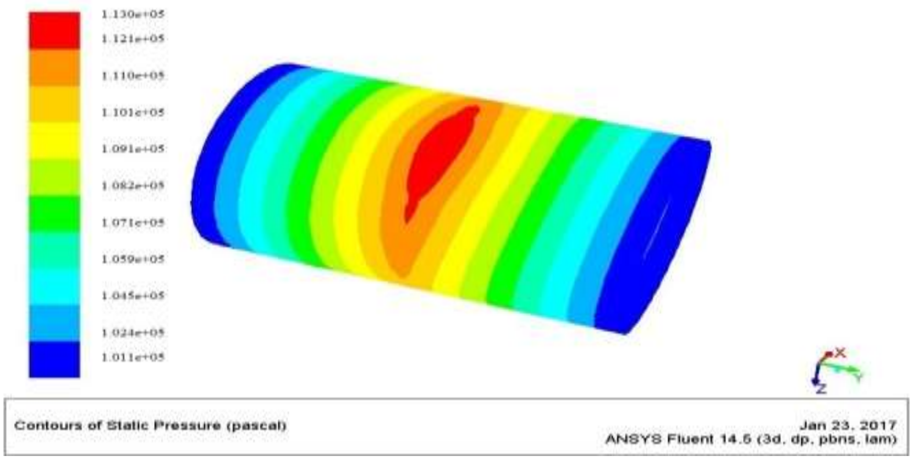

Fig. 3: Thermo-hydrodyanamic pressure with fins journal bearing

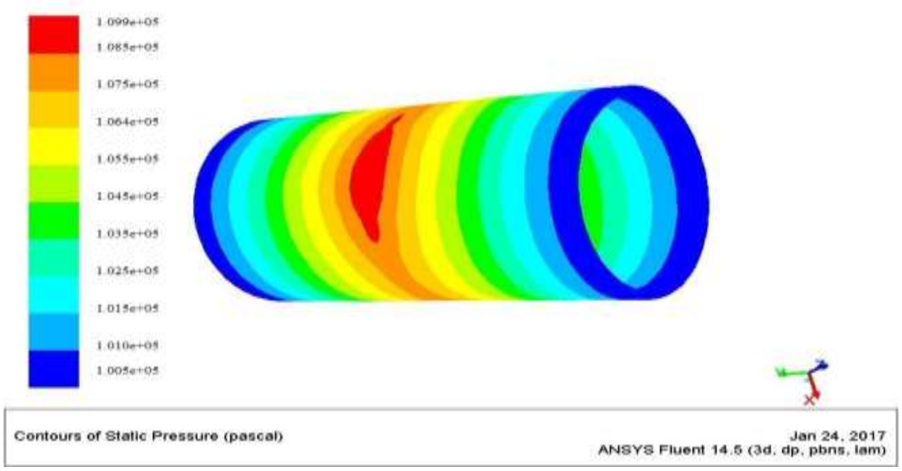

Fig. 4: Thermo-hydrodyanamic pressure without fins journal bearing

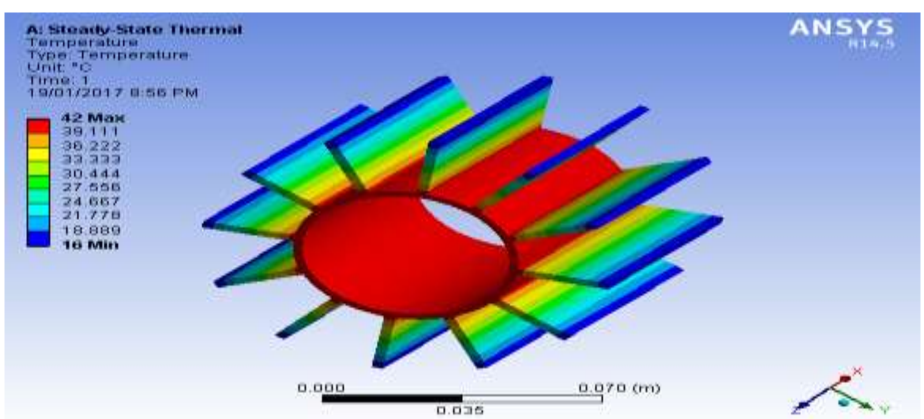

Fig. 5. Temperature distribution of journal bearing

IV.Graph Result of journal bearing

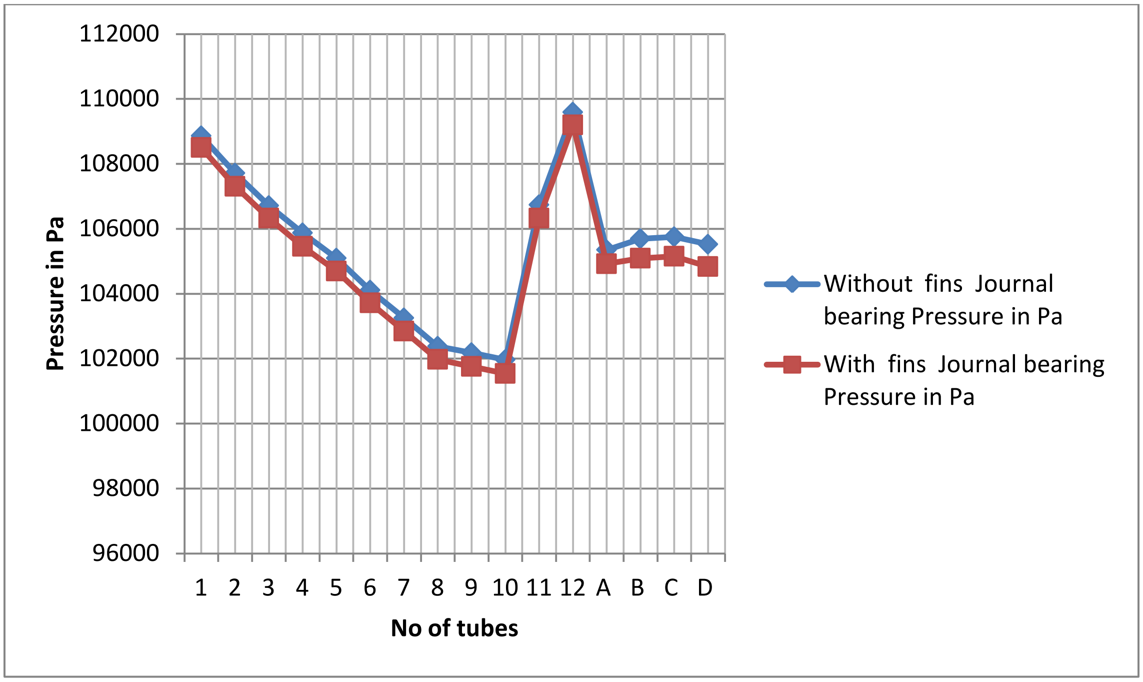

Fig.6 Graph of pressure of withfins and without fins bearing

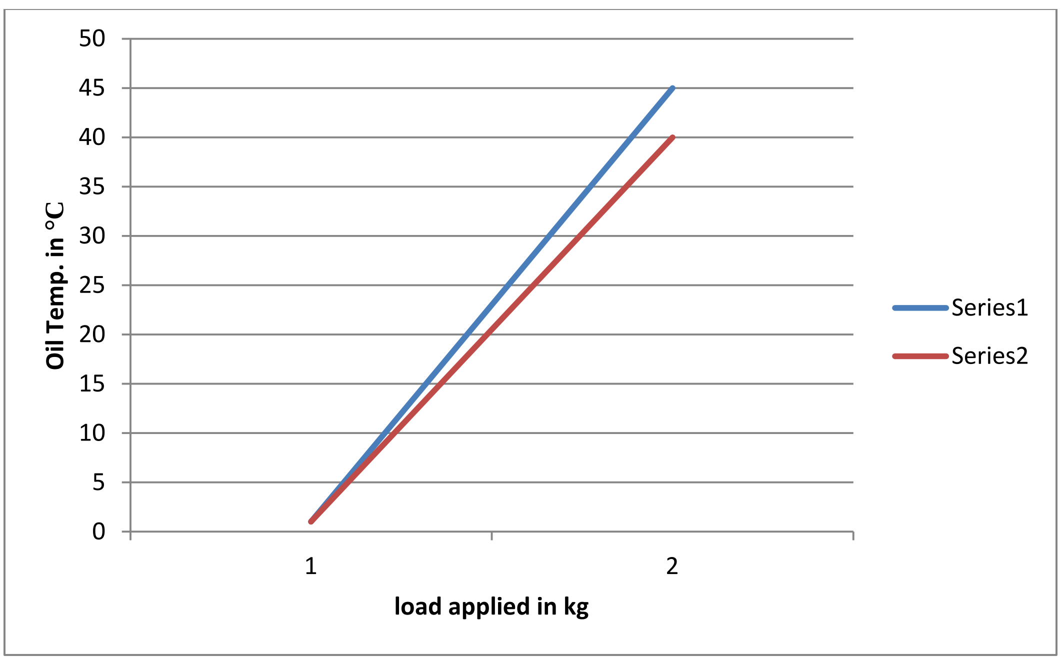

Fig 7. Graph of Temperature wihfins and without fins

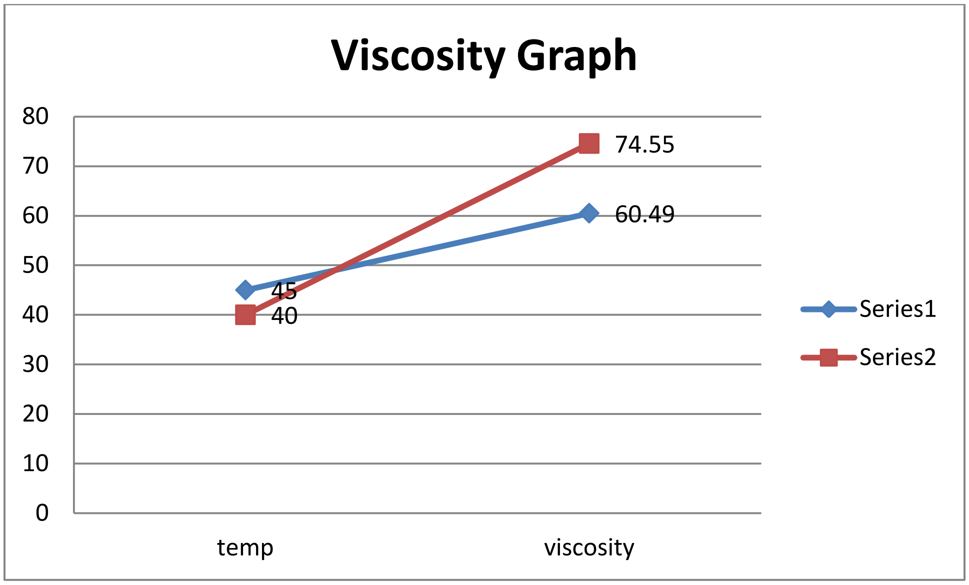

Fig 8. Graph of Viscosity of oil

CONCLUSIONS

Thermo-hydrodynamic analysis for circular journal bearing has been carried out using the application of Computational Fluid Dynamics and applied fins on external surface of journal bearing. It has been found its increased the efficiency of journal bearing and bearing life upto five percentages.

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