ISSN NO. 2320-5407

Journal homepage: http://www.journalijar.com

INTERNATIONAL JOURNAL OF ADVANCED RESEARCH

RESEARCH ARTICLE

Lubrication of Journal Bearing Consider in Thermal Effect in Couple Stress Fluid Considering Cavitation

***V.Bharath Kumar[1], P.Suneetha[1], K.Ramakrishna Prasad[2]**

1. Research Scholar, Department of Mathematics, S.V.University, Tirupati, A.P, India.
2. Professor, Department of Mathematics, S.V.University, Tirupati, A.P., India.

Manuscript Info

Manuscript History:

Received: 18 March 2013
Final Accepted: 01 April 2013
Published Online: April 2013

Key words:
Cavitations,
Couple stress,
Thermal variation,
journal bearing,

Abstract

A Theoretical study of combined effect of thermal variation and couple stresses on journal bearing considering cavitations condition is analyzed. The modified Reynolds equations accounting for the couple stresses and thermal variation is considered. It is to study the effect of couple stresses and thermal variation in journal bearing. Expressions for pressure, Load capacity are studied by evaluating them numerically for various parameters. From the numerical computations of the results it is found that the effect of couple stresses is to decreases the cavitations point increases the load capacity. The effect of thermal factor is to decrease load capacity and increases cavitation point.

Introduction

In general additives are added to the base lubricants to improve the bearing characteristics. Various theories have been proposed for this these additives are generally long chain organic compounds and lot of theoretical working done in shown [1-11]. Most of the theoretical investigation of hydro dynamic lubrication it has been assumed that the bearing surface is smooth .Some experimental studies show that the properties of the lubricants of bearings can be improved when some high-polymer additives are added to mineral oils. A Journal bearing is the hydrodynamic bearing most in use it is a circular shaft or journal rotating inside a circular bush. The inner constituent so at is solid right circular cylinder called 'journal 'and the outer body is in the form of a hollow right circular cylinder called bearing. The inner diameter of the bush is between one and two parts per thousand bigger than the shaft the gap between the cylinders is taken to be very small as compare to the radii of both the cylinders and so that it an thin fluid layer between these two cylinders which may be considering as a lubricants mush work has been done in journal bearing with various lubricants. Cavitations is the formation and then immediate implosion of cavities in a liquid –i,e small liquid free zones ("bubbles") that are the consequence of force acting up on the liquid .it usually occurs when a liquid is subjected to rapid changes of pressure that cause the formation of cavities where the pressure is relatively low. Cavitations is a significant cause of wear in some engineering contexts.(sinha et al.1981) studied the couple stress in journal bearing lubricants.(Articles et al.1985) improved the analysis of starved journal bearing including temperature and cavitations.(Mokhiammer et al.1999)studied the journal bearing lubricated by fluids with couple stress considering the elasticity of the linear.(Jaw-Ren Lin 2002)obtained the effects of couple stresses the lubrication of finite journal bearings.

In this paper the couple stress fluid model is used to investigate the effects of couple stress in lubricants. Mean while the effects of thermal variation and cavitations on the performance of a journal bearing are included.

Corresponding author: *vedagiri.1986@gmail.com*

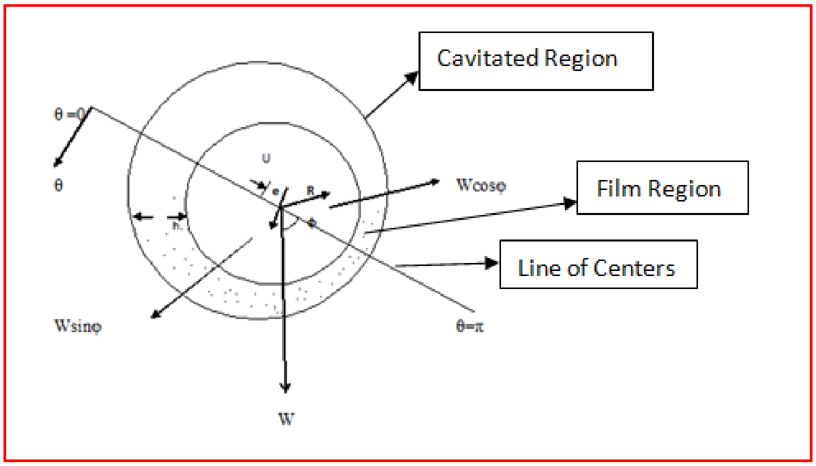


Fig 1.1 journal Bearing Configuration (using Reynolds Boundary conditions)

Method of solution

The problem is considered is that of study laminar flow of an incompressible fluid between two eccentric cylinder in uniform motion. The clearances c between two cylindrical surfaces is small compared with the radios of the inner cylinder (journal). Below one shows journal bearing operating with a constant external load W , and speed U, and the Physical condition imposed the journal operates at an eccentricity e by imposing the Reynolds boundary conditions at the end of the pressure curve. the cavitations occurs the lubrication of partial journal bearings. i,e pressure is always positive tends to zero with a pressure gradient zero. Thus it is assumed that the film is continuous only in the region of positive pressure and that is cavitations at some position θ= θ* >π, where p= $\frac{dp}{d\theta}$ =0 forming a discontinues mixture of air vapor lubricant the cavitated region (θ* <θ<2 π) these conditions have been applied externally in journal bearing analysis[6].

$$\frac{d}{dx}\left[\frac{h^3}{12u}F2\frac{dp}{dx}\right]=u\frac{d}{dx}h \tag{1}$$

Where

$$F2=1-12\frac{l^2}{h^2}+24\frac{l^3}{h^3}\tanh(h\ /2l) \tag{2}$$

Where $l=\left(\frac{n}{\mu}\right)^{1/2}$, μ is the viscosity if the fluid

Here we consider thermal effects taking the viscosity as.

$$\mu=\mu_0(\frac{h}{h_0})^q \tag{2.a}$$

Where q is the thermal factor , 0<q<1

$$Now \qquad x=R\theta,\ dx=Rd\theta,$$

$$\frac{d}{d\theta}\left(\frac{h^3}{12\mu}F2\frac{dp}{d\theta}\right)=uR\frac{d}{d\theta}(h\ ) \tag{3}$$

and when these are substitute in equation(1) the Reynolds equation becomes

The Reynolds boundary conditions for P are

$$p=0, at\theta=0$$

$\frac{dp}{d\theta}=0$, at $\theta=\theta*(\theta*>\pi)$, (4)

$p=0$, at $\theta=\theta^*$

θ^* is the cavitation point

Integrating equation (3) using (4)

$$\frac{h^3}{12\mu}F_2\frac{dp}{d\theta}=uRh+c_1$$

When

$\theta=\theta*,\frac{dp}{d\theta}=0$, h=h*

$$uRh+c_1=0$$

$$c_1=-uRh$$

$$\frac{h^3}{12\mu_0}\left(\frac{h_0}{h}\right)^q F_2\frac{dp}{d\theta}=uRh-uRh^*=uR\left(h-h^*\right)$$

$$\frac{dp}{d\theta}=\frac{uR12\mu_0}{h_0^q}\int_{\theta}^{\theta^*}\frac{h-h^*}{h^3}\frac{h^q}{F_2}d\theta \qquad (5)$$

where

$$h_n^*=c(1+\varepsilon\cos\theta^*)$$

$$p=\frac{uR12\mu_0}{h_0^q}\int_{\theta}^{\theta^*}\frac{h-h^*}{h^3}\frac{h^q}{F_2}d\theta \qquad (6)$$

$$p=\frac{uR12\mu_0}{c^q\left(\frac{h_0}{c}\right)^q}\int_0^{\theta}\frac{c\left(\frac{h}{c}-\frac{h^*}{c}\right)}{c^3\left(\frac{h}{c}\right)^3}*c^q\frac{(\frac{h^q}{c^q})}{\overline{F}_2}d\theta$$

$$\frac{pc^2}{12\mu_0 uR}=\frac{1}{\overline{h_0}^q}\int_0^{\theta}\frac{h-h^*}{\left(\overline{h}\right)^3}*\frac{\overline{h^q}}{\overline{F}_2}d\theta$$

$$\overline{p}=\frac{1}{\overline{h_0}^q}\int_0^{\theta}\frac{h-h^*}{\left(\overline{h}\right)^3}*\frac{\overline{h^q}}{\overline{F}_2}d\theta$$

$$\overline{p}=0 at \theta=\theta^*$$

$$0=\int_0^{\theta^*}\frac{h-h^*}{\left(\overline{h}\right)^{3-q}}\frac{1}{\overline{F}_2}d\theta$$

$$\overline{p}=\int_0^{\theta}\frac{H-H^*}{H^{3-q}\overline{F}_2}d\theta \qquad (7)$$

The non dimensional parameters are

$$H = \frac{h}{c} \qquad H^* = \frac{h^*}{c} \qquad \overline{p} = \frac{pc^2}{12\mu_0 uR}$$

where

$$\overline{F_2} = 1 - 12\frac{l^2}{h^3} + 24\frac{l^3}{h}\tanh\left(\frac{h}{2l}\right) \tag{8}$$

The value of H^* can be found by using $\overline{p}(\theta^*) = 0$

$$\int_0^{\theta^*} \frac{H - H^*}{H^{3-q}\overline{F}_2} d\theta = 0 \tag{9}$$

The load components per unit with normal to the line of center is

$$w_{\frac{\pi}{2}} = w\sin\phi = \int_0^{\theta^*} p\sin\theta R d\theta \tag{10}$$

$$= R\int_0^{\theta^*} p\sin\theta R d\theta$$

$$w_{\frac{\pi}{2}} = R\left[p(-\cos\theta)\right]_0^{\theta^*} - \int_0^{\theta^*} \frac{dp}{d\theta}(-\cos\theta)d\theta$$

$$w_{\frac{\pi}{2}} = w\sin\phi = \int_0^{\theta^*} \frac{dp}{d\theta}\cos d\theta$$

$$= R\int_{\theta}^{\theta^*} \frac{uR12\mu_0}{h_0^q}\frac{h - h^*}{h^{3-q}}\frac{\cos\theta}{F_2}d\theta \tag{11}$$

$$w_{\frac{\pi}{2}} = \frac{uR^2 12\mu_0}{c^q\left(\frac{h_0}{c}\right)^q}\int_0^{\theta^*} \frac{c\left(\frac{h}{c} - \frac{h^*}{c}\right)}{c^{3-q}\left(\frac{h}{c}\right)^{3-q}} * \frac{\cos\theta}{\overline{F}_2}d\theta$$

$$\frac{w_{\frac{\pi}{2}}c^2}{12\mu_0 uR} = \frac{1}{\overline{h_0^q}}\int_0^{\theta^*} \frac{h - h^*}{\left(\overline{h}\right)^{3-q}}\frac{\cos\theta}{\overline{F}_2}d\theta$$

$$\overline{w}_{\frac{\pi}{2}} = \frac{1}{\overline{h_0^q}}\int_0^{\theta^*} \frac{H - H^*}{\left(\overline{H}\right)^{3-q}}\frac{\cos\theta}{\overline{F}_2}d\theta \tag{12}$$

The load components per unit with along the line of center is $w_0 = w\cos\phi$

$$w_0 = -\int_0^{\theta^*} p\cos\theta R d\theta \tag{13}$$

The corresponding non-dimensional form is

$$\overline{w_0} = \frac{1}{\overline{\overline{h_0}^q}} \int_0^{\theta^*} \frac{H - H^*}{(H)^{3-q}} \frac{\sin\theta}{\overline{F}_2} d\theta \tag{14}$$

The non dimensional result load is given by

$$w^* = \left(\overline{w_0}^2 + \overline{w^2{}_{\frac{\pi}{2}}}\right)^{\frac{1}{2}} \tag{15}$$

The graphs for load capacity have been plotted with corresponding to thermal effects and couple stress parameter. From Fig.1

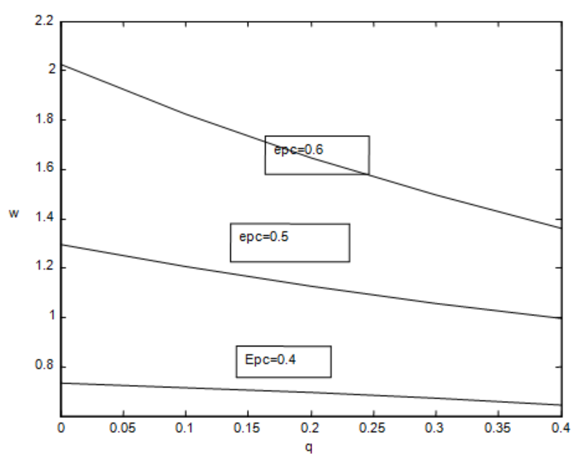


Fig (1) W vs q for different epc

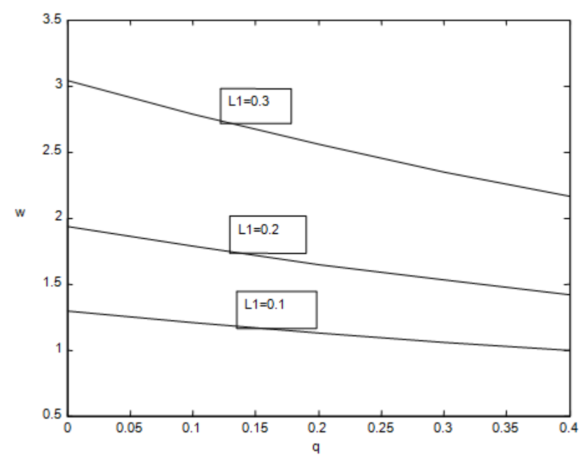


Fig (2) W vs q for different L1

Result and Discussion:

Equation(9) is solved for θ* numerically using bi-section method from the values obtained for θ*. Substituting eq(12),(14) in (15) , we get w* and plotted in fig(1) to (4). In fig (1) the load capacity w is plotted against thermal effect for different values of ε, eccentricity ratio the load capacity decreases as the thermal effect q increases and also it increases as ε increases. In fig (2) the load capacity w is plotted against thermal effect for different values of l1, couple stress parameter. Load capacity decreases as the thermal effect q increases and also it increases as l1 increases. In fig (3) the load capacity w is plotted against couple stress parameter l1 for different values of eccentricity, the load capacity increases as the couple stress parameter l1 increases and also it increases as ε increases. In fig (4) the load capacity w is plotted against couple stress parameter l1 for different values of q, the load capacity w increases as the couple stress parameter l1 increases and also it decreases as q increases.

Hence the load capacity increases due the couple stress parameter, decreases due the thermal factor. Whereas the cavitations point decreases due to the couple stress parameter, increases due to the thermal factor.

From Tab(1) cavitation point for different couplestress parameter have been found, It is seen that cavitation decreases as couplestress parameter increases. From tab(2) cavitation point for different parameter have been obtained,it is seen that cavitation point increase due to the thermal parameter.

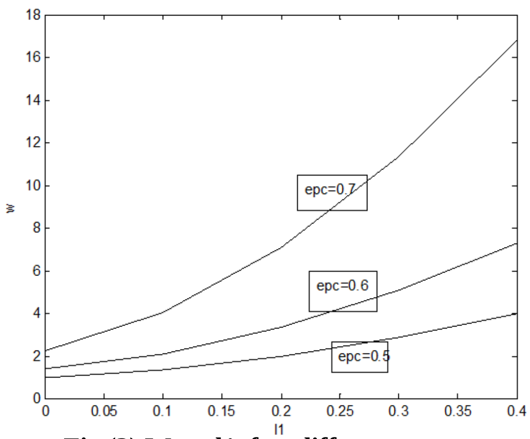
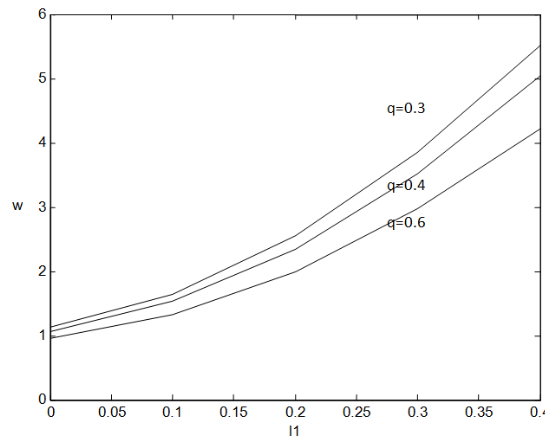


Fig (3) W vs l1 for different epc



Fig(4) W vs l1 for different q

C	L1
3.319885253906250	0.001
3.319763183593750	0.002
3.319519042968750	0.003
3.319152832031250	0.004
3.318786621093750	0.005
3.318176269531250	0.006
3.317565917968750	0.007
3.316833496093750	0.008
3.316101074218750	0.009
3.315124511718750	0.010

Cavitation point C for various values of l1

C	Q
3.030578613281250	0
3.074768066406250	0.5
3.120300292968750	0.1
3.167297363281250	0.15
3.215637207031250	0.2
3.265319824218750	0.25
3.316345214843750	0.3
3.368469238281250	0.35
3.421813964843750	0.4
3.476257324218750	0.45
3.531677246093750	0.5
3.588073730468750	0.55

Cavitation point C for various values of q

Summary:

In this chapter the generalized Reynolds equation for couplestress parameter have been derived .The effects of couple stress and thermal effect in journal bearing considering cavitation. Expression of pressure, load capacity, and point of cavitation have been obtained and were numerically analyzed. The effects of couple stress with eccentricity ratio, cavitation is analyzed.

It is found that the effect of couplestress increases the point of cavitaion and it is decreases and with the increase of thermal factor . The effect of couple stress parameter and thermal factor is investigated on load capacity.

NOMENCLATURE

C	Radial clearance
e	Eccentricity
ε	Eccentricity ratio
h	film thickness
h*	film thickness at the cavitation point
H	Dimensionless oil film thickness
R	Radius of journal bearing
U	rotational velocity of journal bearing
l	couple stress parameter
θ^*	cavitation point
x,y,z	Cartesian coordinates
p	Hydrodynamic pressure
W	Resultant load carrying capacity
W_0	Load component along the line of center
$W_{\frac{\pi}{2}}$	Load component normal to the line of center
W^*	Resultant dimensionless load
θ	Angular Coordinate

REFERENCES

1. **Abdullah A. Elsharkawy and Lotfi H. Guedour (2001).** An inverse Solution For Finite Journal lubricated With Couple Stress Fluids,Tribology International,Vol.34,pp.107-118.

2. **Hsin-Lu Chang,Cheng-Hsing Hsu and Jaw-Ren-Lin (1999).** Lubrication performance of Finite journal Bearing lubricated by Fluids With Couple Stress considering The Elasticity of The linear, Wear,Vol.224,PP.194-201.

3. **Mokhimmer, V.M., Crosby, W.a .and El-Hamal, W.A (1999).** A Study of Journal Bearing lubricated by fluid with Couple Stress Considering the elasticity of the linear, Wear, Vol.224,PP.194-201.

4. **Nadivinamani, N.B., Syeda tasneem Fathima and Hiremath, P.S (2003).** Hydrodynamic lubrication of rough slider bearing With Acouple Stress Fluids Tribology International,Vol.36,PP 949-959.

5. **Nadivinamani, N.B. Hiremath,P.S. and Gurubasavaraj G (2002).** Surface roughness effect in a Short porous journal bearing with a couple stress fluid, Fluid dynamics Research,vol.36,PP.333-354.

6. **Prawal Sinha ,and Chandan singh (1981).** Couple Stress in The lubrication of rolling contact bearings considering Cavitation,Vol.67,PP.85-98.

7. **Shukla,J.B.and Prasad,R (1966).** The Effects of roughness In Hydro magnetically lubricated bearings, ASME, Lub.NewYork,Vol.9.PP 66.

8. **Shukla,J.B (1977).** A New theory of lubrication of rolling contact bearing considering cavitation,wear,Vol.44,PP.295.

9. **Sinha. p., Singh,C.and Prasad,K.R (1981).** Couple stress in journal bearing lubricants and the effect of cavitation, wear, vol.67,PP.85.

10. **Xiao-Li Wang, Ke-Qin Zhn and Shi-Zhu Wen (2002).** On The performance of dynamically loade journal bearings lubricated with couple stress fluids, Trobology International, Vol.35.PP.185-191.

11. **Artiles, A. and Heshmat, H (1985).** Analysis of starved journal bearings including temperature and cavitation effects, ASME Journal of Lubrication Technology, pp. 1-13.