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LUBRICATED SPHERICAL BEARINGS WITH SURFACE ROUGHNESS

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ABSTRACT

The generalized Reynolds equation derived for rough surfaces applied to squeeze films compare with roughness and without roughness in spherical bearings. The effect of longitudinal roughness decreases the load capacity transversal roughness increases the load capacity.

I. INTRODUCTION

The phenomenon of two lubricated surfaces approaching each other with a normal velocity is known as squeeze film lubrication. The thin film of lubricant present between the two surfaces acts as a cushion and it prevents the surfaces from making instantaneous contact. The time required to squeeze out the lubricant depends upon surface configuration, fluid properties and the load applied. In general, the relation between the load carrying capacity and the rate of approach is studied in the most squeeze film analysis. Much work is done in this line and the mathematical review on such process was done by various workers.[1-47]

Although squeeze film lubrication has been generally understood for sometimes, the importance of applications lead to draw the attention of many workers in sixties. Pan et.al [31] studied the theory and experiments of squeeze film bearing parti-cylindrical journal bearings. Jacson.J.D [21] studied a study of squeezing flow. Gould.P [15] studied about parallel surface squeeze films: The effects of variation of viscosity with temperature and pressure. Beck et.al [5] studied flat disk squeeze film bearing including the effects of supported mass motion. Ramaiah.G and Dubey J.N [35] studied squeeze films and thrust bearing using Micropolar fluid. Murti.P.R.K [27] studied squeeze films in porous bearings.

J.B.Shukla, K.R.Prasad and P.Chandra studied various squeeze films using power law fluid [22].

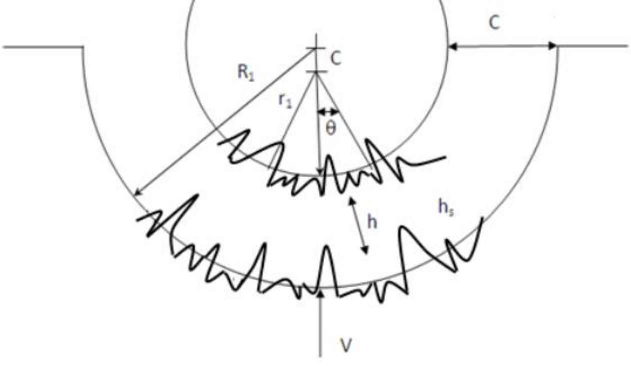

Fig 1: squeeze film

In this, the generalized Reynolds equation derived for rough surfaces applied to squeeze film bearings and the effects of surface roughness on these Spherical squeeze films is studied Using **Analytical methods with different Parameters**.

II. SQUEEZE FILM LUBRICATION IN SPHERICAL BEARING

Consider squeezing between two eccentric spherical surfaces of radii r_i and R_i which are approaching each other with a normal velocity V as shown in Fig (1.1)
The film thickness h is given by h = c(1- εcosθ). Where c =R_1-r_1 is the clearance width and ε = e/c is the eccentricity ratio.
The flow flux in this case is obtained by

$$Q=\left[\frac{F}{r}\,\frac{dp}{d\theta}\,2\pi r_1\sin\theta\right] \tag{1.1}$$

The flux Q obtained from the equation of continuity is

$$Q=2\pi r_1 V\sin^2\theta \tag{1.2}$$

Where

$$F=\frac{M-Tanh\left(M\right)}{M^3}\,\frac{\left(2h_s\right)^3}{2k\mu}+\frac{1}{4}\left[\frac{c\left(1-\varepsilon\cos\theta\right)}{2}+2h_s\,\frac{Tanh\left(M\right)}{M}\right]^2 4h_s\,\frac{Tanh\left(2M\right)}{k\mu\left(2M\right)} +\frac{1}{12\mu}\left(\left(\frac{c\left(1-\varepsilon\cos\theta\right)}{2}-2h_s\right)^3\right) \tag{1.3}$$

The boundary condition for (3.2) is

$$p=0 \quad at \qquad \theta=\frac{\pi}{2}$$

Integrating equation and using the above condition, we get the expression for pressure distribution as

$$p(\theta)=\int_0^{\pi/2}\left[\frac{r_1^2V\sin\theta}{F}\right]d\theta \tag{1.4}$$

The load capacity W is given by

$$W=2\pi r_1^2\int_0^{\pi/2} p\sin\theta\cos\theta\,d\theta \tag{1.5}$$

Using (1.4) in (1.5) we get the load capacity was

$$W=\pi r_1^4V\int_0^{\pi/2}\left[\frac{\sin^3\theta}{F}\right]d\theta \tag{1.6}$$

If we take roughness is zero means $h_s = 0$ then the load capacity becomes

$$W_{0,1}=\pi r_1^4V\int_0^{\pi/2}\left[\frac{\sin^3\theta}{F_1}\right]d\theta \tag{1.7}$$

Where

$$F_1=\left[\frac{c\left(1-\varepsilon\cos\theta\right)}{2}\right]^3$$

By comparing the load capacity with and without roughness, we get the resultant non dimensional load as

$$\overline{W} = \frac{W_{hs,k}}{W_{0,1}} = \frac{\int_0^{\pi/2}\left[\frac{\sin^3\theta}{F_1}\right]d\theta}{\int_0^{\pi/2}\left[\frac{\sin^3\theta}{F_2}\right]d\theta} \tag{1.8}$$

And squeeze time $\bar{t}$ for the surfaces to approach from the initial eccentric position (ε= 0) to a final eccentric position ($\varepsilon = \varepsilon_1$) and by taking roughness is zero, we get

$$\overline{t} = \frac{t_{hs,k}}{t_{0,1}} = \frac{\int_0^{\varepsilon_1} I_1\,d\varepsilon}{\int_0^{\varepsilon_1} I_2\,d\varepsilon} \tag{1.9}$$

Where

$$I_1 = \int_0^{\pi/2}\left[\frac{\sin^3\theta}{F_1}\right]d\theta \quad I_2 = \int_0^{\pi/2}\left[\frac{\sin^3\theta}{F_2}\right]d\theta$$

The graphs are plotted for equations (1.8) and (1.9) are analyzed numerically.

2.1 GRAPHS

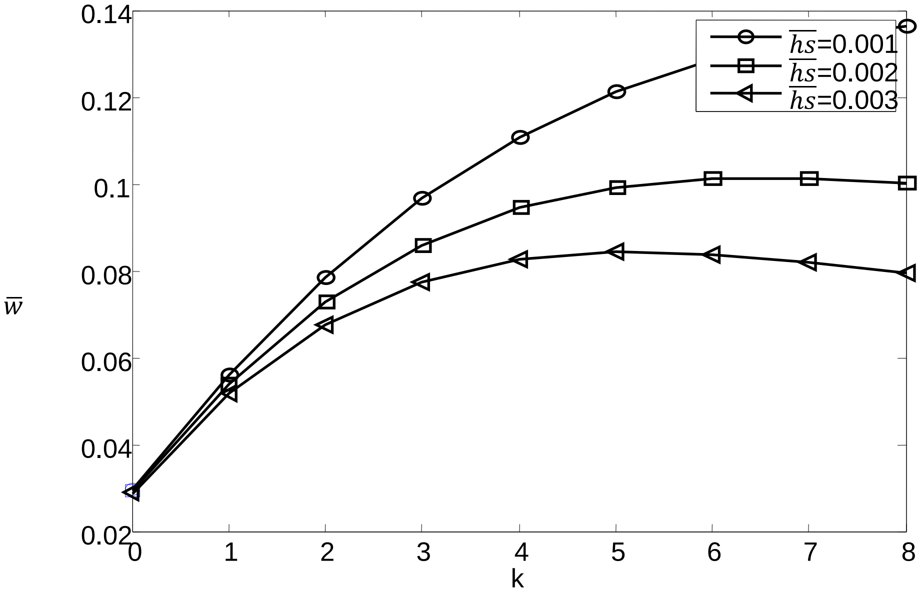

Fig 2: Load carrying capacity Vs K for various $\overline{hs}$

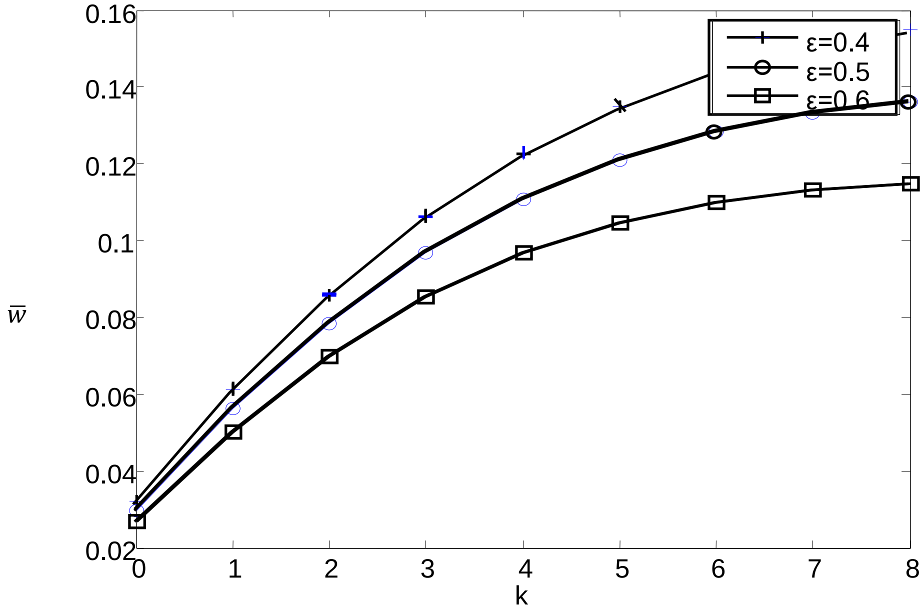

Fig 3: Load carrying capacity Vs K for various ε

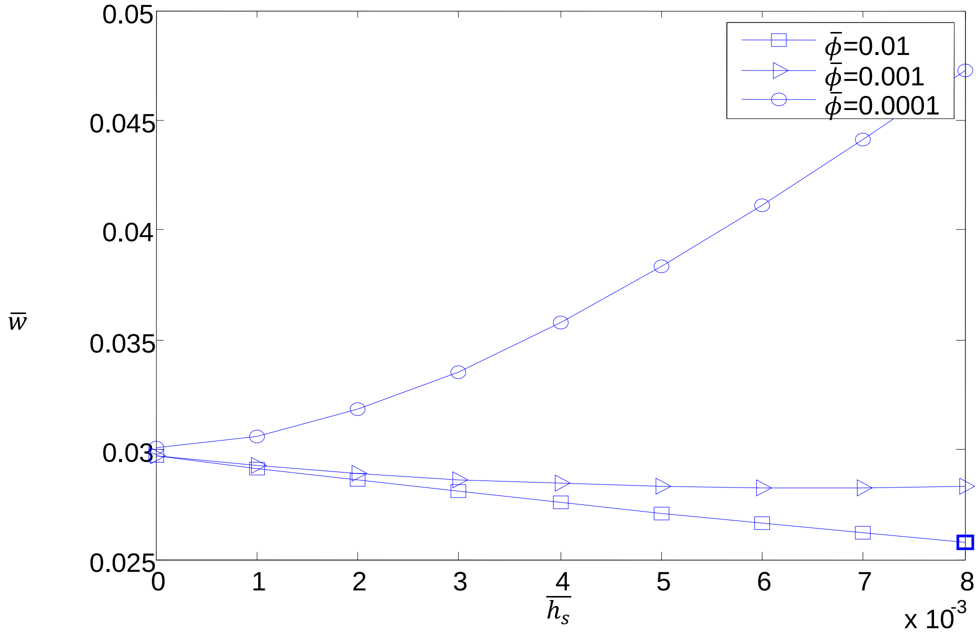

Fig 4: Load carrying capacity Vs $\overline{hs}$ for various $\bar{\phi}$

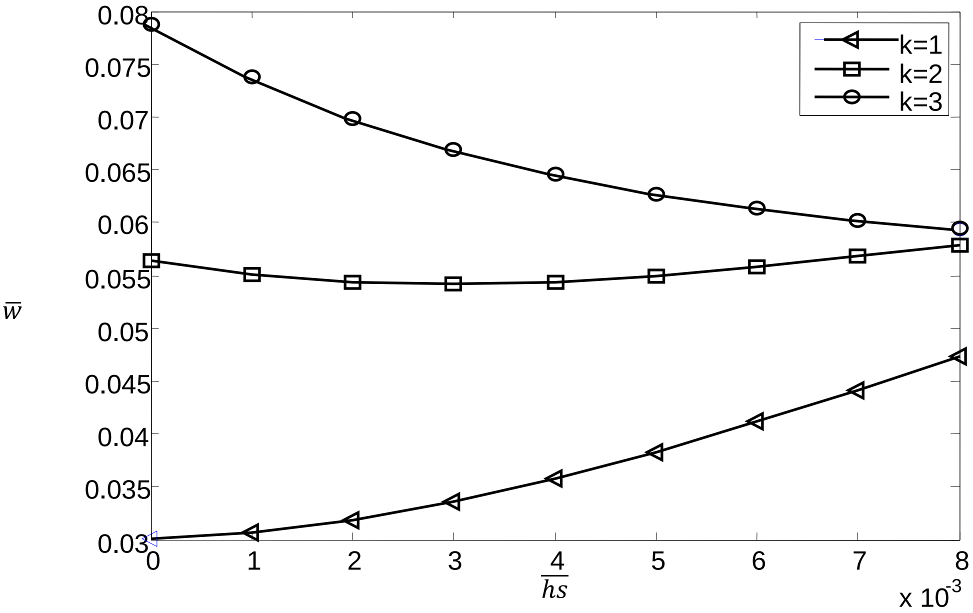

Fig 5: Load carrying capacity Vs $\overline{hs}$ for various k

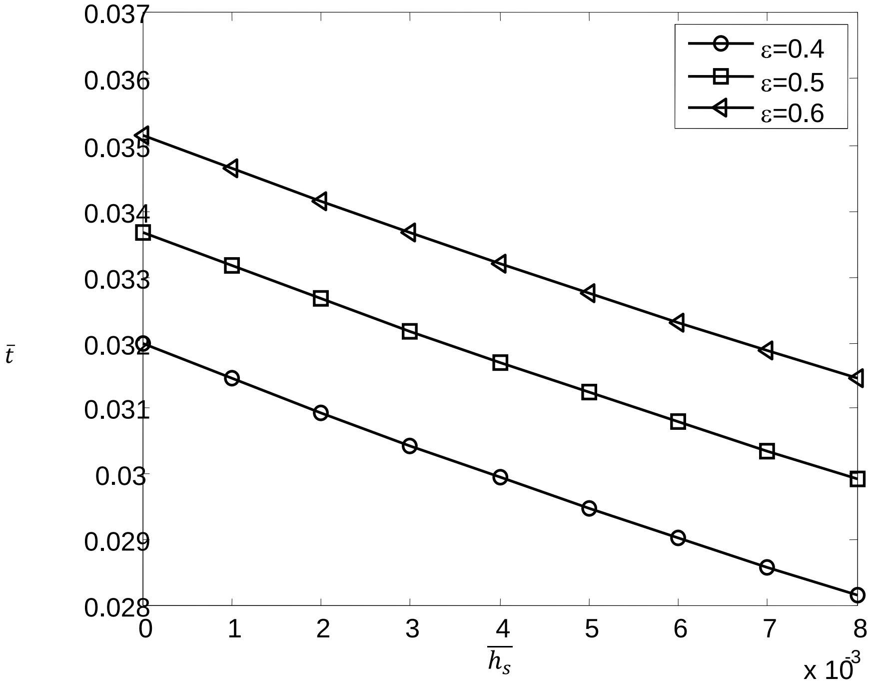

Fig 6: Squeezing time Vs $\overline{hs}$ for various ε

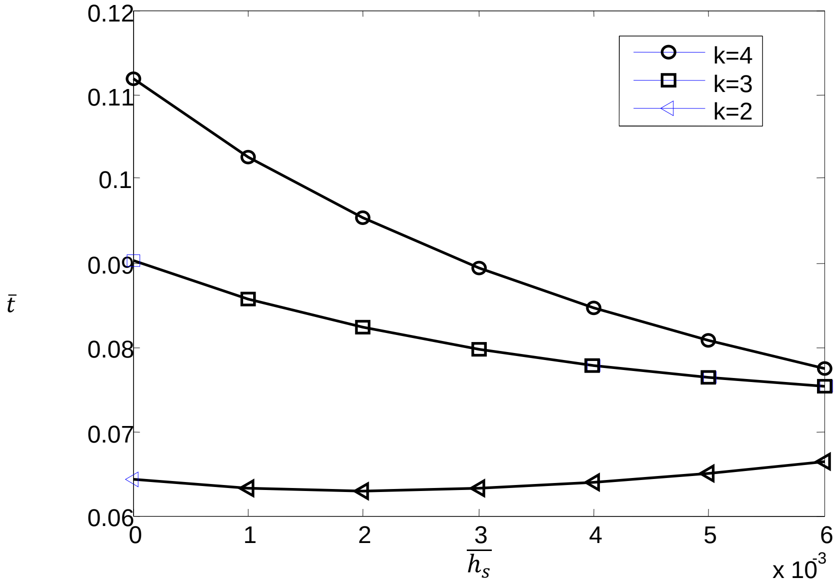

Fig 7: Squeezing time Vs $\overline{hs}$ for various k

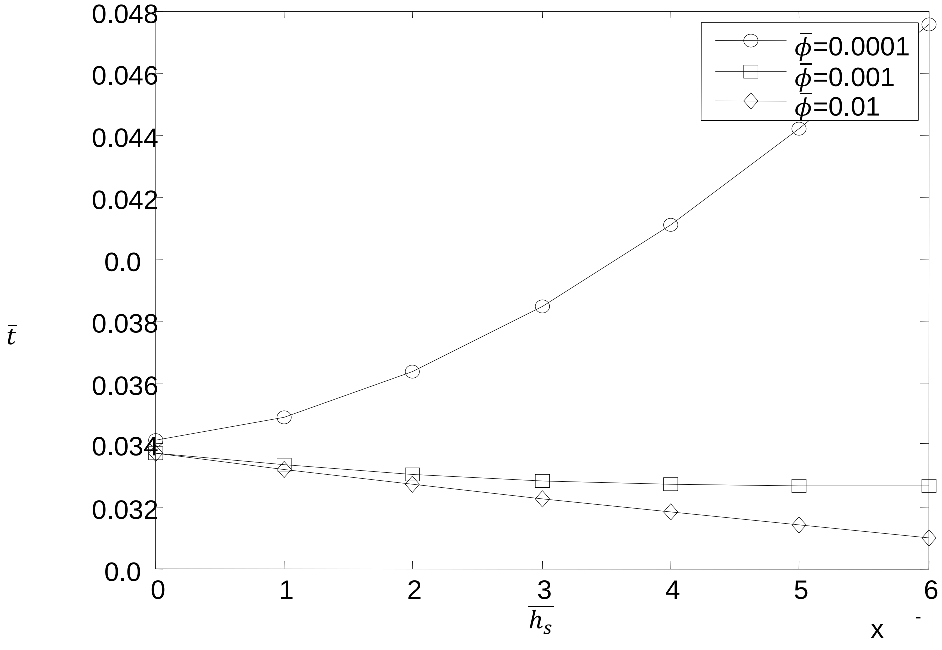

Fig 8: Squeezing time Vs $\overline{hs}$ for various $\bar{\phi}$

III. RESULTS AND DISCUSSION

Figures 2 to 8 are drawn for load capacity and squeezing time are plotted with k, $\overline{h_s}$for various parameters ε, $\bar{\phi}$.

Fig 2 is plotted for load capacity Vs K for different $\overline{h_s}$. From this figure we can say with the increase of k the load capacity increase and with the increase of roughness $\overline{h_s}$ the load decreases.

Fig 3 is plotted for load capacity Vs K for different ε. From this figure we can say with the increase of k the load capacity increase and with the increase of eccentricity ε the load decreases.

Fig 4 is plotted for load capacity Vs $\overline{h_s}$for different $\bar{\phi}$. From this figure we can say with the increase of $\overline{h_s}$ the load capacity decrease for low values of $\bar{\phi}$and increases for high values of εwith the increase of roughness $\bar{\phi}$ the load decreases. Here high values of $\bar{\phi}$ may represent longitudinal roughness.
Fig 5 is plotted for load capacity Vs $\overline{h_s}$ for different k. From this figure we can say with the increase of $\overline{h_s}$ the load capacity decrease and increases with the decrease of k.
Fig 6 is plotted for squeezing time Vs $\overline{h_s}$ for differentε. From this figure we can say with the increase of $\overline{h_s}$the squeezing time decreases and with the increase of ε squeezing time increases.
Fig 7 is plotted for squeezing time Vs $\overline{h_s}$ for different k. From this figure we can say with the increase of $\overline{h_s}$the squeezing time decreases and with the increase of k the squeezing time increases.
Fig 8 is plotted for squeezing time Vs $\overline{h_s}$ for different$\bar{\phi}$. From this figure we can say with the increase of $\overline{h_s}$the squeezing time decreases for high values $\bar{\phi}$ and increase for low values of $\bar{\phi}$. Here low values of $\bar{\phi}$ may represent transverse roughness.

IV. CONCLUSION

From the above graphs we can conclude that

1. When Viscosity increases the load capacity increases with decreasing of eccentricity of Spherical surfaces.
2. When surfaces roughness increases the load capacity decreases with increasing viscosity.
3. When increasing of Surfaces roughness squeezing time decreases with increasing of viscosity.

V. SUMMARY

In this paper the generalized Reynolds equation derived for rough surfaces applied to compare with roughness and without roughness on squeeze films in spherical bearing. The effect of longitudinal roughness decreases the load capacity transversal roughness increases the load capacity.
Further we can investigate the relation between the load capacity and the rate of different approaches in squeeze films, a study of squeezing flow, a study of parallel surfaces squeeze films, and the effects of variation of viscosity with temperature and pressure.
We investigate the effects of Micro polar fluid in porous bearings using power law fluid.

NOMENCLATURE

c	Clearance width in journal bearing or spherical bearing
h	Film thickness of hydrodynamic Zone
h_n	Nominal film thickness
h_s	Mean height of roughness asperities
k	Ratio of viscosities in different layers
p	Hydrodynamic pressure
r_1	Radius of the journal or the radius of the spheres
R_1	Radius of the bearing
V	Squeeze velocity
W	Load capacity for stiff surfaces
X	Cartesian coordinate in the direction of flow
μ	Viscosity of the purely hydrodynamic zone
ε	Eccentricity ratio

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