Mathematical Analysis of Squeeze Film Lubrication between the Parallel Disk

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Abstract

Presented herein are the analytical studies of lubrication mechanism of two parallel disk. The idealized model is to produce the result consistent with those in normal situation. It has been observed that the radial velocity decreases with the increase of h, z. Also it has been observed that radial pressure of squeeze film increases with the increase value of R and decreases with the increase the value of h. Again it has been observed that exterted force decreases with increase the value of film thickness and increases with the increase the value of R. Also it is clear that radial pressure and exterted force increases with the increase of viscosity of liquid.

KEYWORDS: Lubrication, Film thickness, Exterted force, Squeeze film, Non-newtian fluid.

Introduction

When two dry metallic surface more relatively in contact, the motion of these surfaces gives rise to friction. These undesirable effects can be presented by the use of substance is called lubricants such as greases and oils between the relatively moving parts. The function of the lubricant is hold the relatively moving surfaces aparts, to slide on each other with a minimum efforts.

The basic mechanism can be explained in the following way, when a viscous lubricant flow between the squeeze film. It is necessary to have the film thickness and the inlet greater than at the outlet. Rayleigh [1] was first to analyse such type of bearings. Prakash [2] discussed the effect of transverse magnetic field on the ratio of flat and inclined parts under general load condition. Yadav A.K. and Pokhriyal [3] discussed the load capacity of a composite slider for various values of parameter. Yadav A.K. and Kumar.S.[4] investigated the load capacity of a slider bearing.

The visco-elastic fluids which possess highly elastic properties can be used in preparing thin material sheet when they are forced between two rollers surface, which are moving at very high speeds. This prosess is calendaring. Lubricants are backbone of any industry. Any moving mechanical device need lubricants for smooth functioning. Incompressible fluids were being used as lubricants but researchers used non-newtian fluids as lubricant and studied their behavior analytically.

From the mathematical point of view the study of hydrodynamic lubrication in the study of Nevier-stokes equation under certain simplifying assumptions depending upon the configuration of bearing which used as lubricant. The lubricationproblems are mainly concerned with the flow and deformation of lubrication between solid bodies as they slider, rotate to each other. Machine bearing rotate at every high speed. Squeeze film lubrication between the approaching surface. One surface is rigid plate and the other is a porous rectangular plate. The mechanism of lubrication of the joint has for many years drawn both engineer and orthopedic surgeons. Their interest in the field increases various investigation.

In this paper we have made an attempt to study the exterted force on one plate when disk are slowly pressed together with constant speed.

Formulation of the problem

The bearing model considered for the present analysis of the configuration. It consists of two rectangular squeeze film plates.

The equation of continuity;

$$\frac{1}{r}\frac{\partial}{\partial r}(rv_r) + \frac{dv_z}{dz} = 0 (1)$$

Or

$$\frac{dv_z}{dz} = -\frac{1}{r}\frac{\partial}{\partial r}(rv_r) = 0 \ (2)$$

But the L.H.S of equation (1) is a function of z only, the R.H.S has to be some function of z. then

We get

$$v_r(r, z) = r.g(z) \ \ (3)$$

$$0 = -\frac{\partial p}{\partial r} + \mu r \frac{d^2}{dz^2} g(z) \ (4)$$

$$\rho v_z \frac{dv_z}{dz} = \mu \frac{d^2 v}{dz^2} \ (5)$$

With boundary conditions;

$$v_z(h) = h' = constent \ \ \ (6)$$

$$v_z = 0, \ \ z = 0 \ \ (7)$$

$$v_r = 0 \ , \ \ z = h \ (8)$$

Solution of the problem

Integration equation (1) over the cylindrical flow and using the boundary condition; we get:

$2\int_0^h v_r(v,z)dz + rh' = 0$ (9)

Integrating equation (5) with respect to z twice, and

Using the boundary conditions (6), (7) & (8), we get

$-\frac{dp}{dr}\frac{h^2}{2} = -\frac{dp}{dr}\frac{z^2}{2} + \mu v_r$ (10)

From equation (3) & (10), we get

$v_r = \frac{h^2 r}{2}\left(-\frac{1}{\mu r}\frac{dp}{dr}\right)\left[1-\left(\frac{z}{h}\right)^2\right]$ (11)

From equation (9) and (11), we have

$v_r = \frac{3}{4}\left(-\frac{h'}{h}\right) r \left[1-\left(\frac{z}{h}\right)^2\right]$ (12)

The radial pressure distribution

$p - p_0 = \frac{3(-h')\mu R^2}{4h^3}\left[1-\left(\frac{r}{R}\right)^2\right]$ (13)

The exterted forceon one plate

$F(t) = \int_0^{\pi}\int_0^{R}(p-p_0)[t\,\tau_{zz}])\,rdrd\theta$ (14)

Where

$\tau_{zz} = 3\left(-\frac{h'}{h}\right)\mu\left[1-\left(\frac{z}{h}\right)^2\right]$ (15)

Then

$$F(t) = \left(\frac{3\pi R^4\mu(-h')}{8h^3}\right)$$

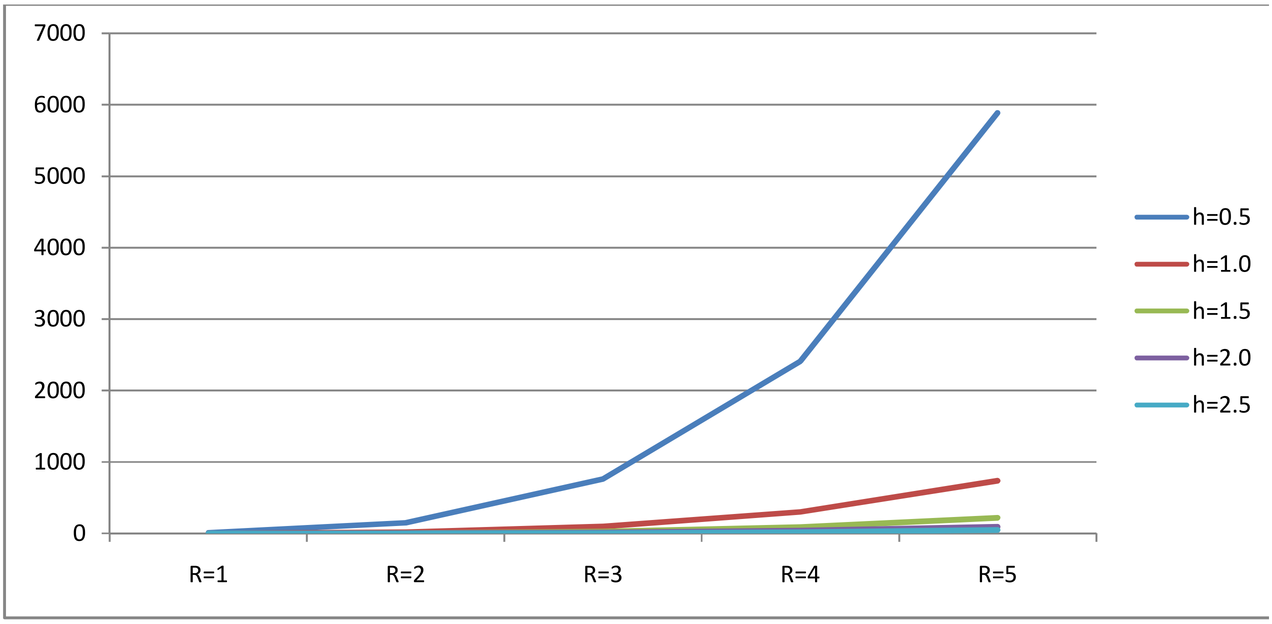
Result and discussion

The present paper proposes a more realistic model for explaining the lubrication mechanism occurring normally two parallel disk. The result of velocity, pressure and exterted force on the plate have been examined for different value of parameter h, z, r, μ, h' and R. it is clear that the velocity of squeeze film decreases with the increase the value of h and z. Again the value of radial pressure increases with the increase the value of R and decreases with increase the value of h. Also the extorted force decreases with the increase the value of film thickness increases with the increase the value of R.

We have also observed that radial pressure and extorted force increases with the increase of viscosity.

Table

R \ h	0.5	1.0	1.5	2.0	2.5
1	9.42000	1.1775	0.3488	0.1472	0.07536
2	150.72000	18.84000	5.5822	2.3550	1.2058
3	763.02000	95.3775	28.2600	11.9222	6.1042
4	2411.5200	301.4400	89.3156	37.6800	19.2921
5	5887.5000	735.9375	218.992	91.9922	47.1000



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