ISSN 2231-5063 Impact Factor : 4.6052(UIF) Volume - 6 | Issue - 5 | November - 2016

GRT Golden Research Thoughts

HYDRODYNAMIC LUBRICATION OF MICRO-POLAR FLUID IN A SLIDER BEARING

Mr. Sushil Kumar[1] and Dr.A.K. Yadav[2]
[1]Deptt. Of Mathematics Bhagwant University Ajmer(RAJ.)
[2]Deptt. Of Mathematics , Govt. P.G. College , Datia (M.P)

ABSTRACT

Presented here in the study of hydrodynamic lubrication of micro-polar fluid in a slider bearing. It has been observed that the load capacity increases with the increase in the value of coupling constant μ_v/γ_v *and* k_v/γ_v *. The micro-polar fluid under consideration proves to be better lubricant for the slider bearing. The increase in the length of the flat part of the slope inclined part also increase the load capacity.*

KEYWORDS: *Lubricant , Micro-Polar Fluid , Pressure , Load Capacity .*

INTRODUCTION

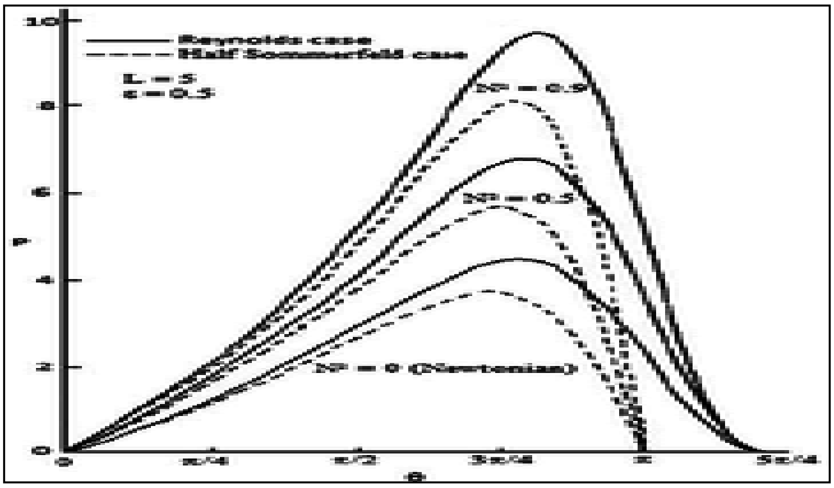
Lubricationtheorynormallystart with the Plane Inclined Pad. This was not done as a converging–diverging plane wedge has a discontinuity at the origin. Rayleigh [5] was first to analyze such type of bearings. He investigated that a combination of flat and inclined parts of a slider is define tally better than a simple slider. Prakash [3] discussed the Effect of transverse magnetic field on the ratio off lat and inclined part sunder general load condition. Pokhriya land Yadav [2] discussed the load capacity of a composite sliderfor various values of parameters . Due to wide application ofsuch type of flow pattern in hydraulic machines and engineering, it is necessary to investigateanalyticallythe slider bearings flowbehavior ofmicro-polar fluidswhich are importantfrom the industrial and technological point of view .

Erigena [1] explained that the classical theory of micro-polar fluids might serve as a satisfactory model for predicting the flow behavior of certain polymeric fluid, fluid containing suspended particles and particularly the animal blood. Ranuka [4] has studied the steady flow problem for micro-polar fluids in a straight channel and circular tube .Willson [6] investigated the stability of micro-polar fluid down as inclined plane.

In this paper, we have used a sliderbearing with the micro-polarfluid as lubricant .

FORMULATION OF THE PROBLEM

Thebasic field equation formicro-polar fluidsin the vector formare given by the followingset of equations ;



$$\nabla . \bar{v} = 0 \qquad (1)$$

$$(\lambda_v + 2\mu_v + k_v) \nabla\nabla.\bar{v} - (\mu_v + k_v) \nabla \times \nabla \times \bar{v} + k_v \nabla \times \bar{v} - \nabla\bar{p} + \rho f = \rho \frac{d\bar{v}}{dt} \qquad (2)$$

$$(\alpha_v + \beta_v + \gamma_v) \nabla \nabla \bar{v} - \gamma_v \nabla \times \nabla \times \bar{v} + k_v \nabla \times \bar{v} - 2k_v\bar{v} + pl = p\, j\dot{v} \quad (3)$$

Whereα_v ,β_v ,γ_v , λ_v ,μ_v and $k_v$are six material constants, of represented body force, **r**epresents the body coupleand$\bar{V}$and$\dot{J}$represented the micro-rotation and gyration constant respectively. The equation determining the velocity field within the fluid in motion, are in general inter-related .Neglecting the velocity derivatives with respect to the axial distance and leaving the Inertia terms ,we get the followingequations governingthe motion of micro-polar fluid for the two dimensional sliderbearing flow;

$$(\mu_v + k_v)\frac{\partial^2 u_x}{\partial y^2} + k_v \frac{\partial v_x}{\partial y} - \frac{\partial p}{\partial x} = 0 \quad (4)$$

$$\gamma_v \frac{\partial^2 v_x}{\partial y^2} - k_v \frac{\partial u_x}{\partial y} - 2k_v v_x = 0(5)$$

The equation (4) and (5) are solvedunder the boundary conditions;

$$u_x = 0 \quad \text{at } y = h$$

$$\frac{\partial u_x}{\partial y} = 0 \quad at\ y = 0 \qquad (6)$$

$$v_x = 0 \quad \text{at } y = \pm h$$

Weintroduce the following non-dimensional quantities;

$$u_x = U_\circ u \,, y = hy^*$$

$$v_x = \frac{U_\circ v}{h_\circ}, x = H x^*$$

$$n_2 = \frac{\mu_v}{\gamma_v} h_\circ^{\,2} \quad , n_3 = \frac{k_v}{\gamma_v} h_\circ^{\,2}$$

$$p_x = \frac{u_\circ(\mu_v + k_v)p}{L} \quad (7)$$

Thegoverning equationtake the formafter using (7);

$$\frac{\partial^2 u}{\partial y^{*2}} + \frac{n_3}{n_2 + n_3}\frac{\partial v}{\partial y^*} - \frac{\partial p^*}{\partial x^*} = 0 \ (8)$$

$$\frac{\partial^2 v}{\partial y^{*2}} - n_3 \frac{\partial u}{\partial y^*} - 2n_3 v = 0 \ (9)$$

The slider bearing

$h = h_\circ\left(1 + \frac{mx}{H}\right)$ (10)

or

$h^* = 1 + mx^*$ (11)

Theboundary condition (6) reduces to;

u = 0 at $y^* = h^*$

$\frac{\partial u}{\partial y^*} = 0$ at $y^* = 0$

v = 0at y = $\pm h^*$ (12)

SOLUTION OF THE PROBLEM

Solving the equation (8) and (9) under the boundary condition given by (12) we get;

$$u = 1 + \frac{\partial p^*}{\partial x^*}\left[\frac{n_2+n_3}{2n_2+n_3}(y^{*2} - h^{*2}) - \frac{h^*(n_2+n_3)}{(n_3+2n_2)^2}\frac{\propto(\cos h\propto y^* - \cos h\propto h^*)}{\sin h\propto h^*}\right] \quad (13)$$

and

$$v = \frac{n_3}{\propto^2}\frac{\partial p^*}{\partial x^*}\left[h^*\frac{\sin h\propto y^*}{\sin h\propto h^*} - y^*\right] \quad (14)$$

Where $\propto^2 = \frac{n_3\,(2n_2+n_3)}{(n_2+n_3)}$ (15)

Thevolumetric flow rate is given by

$$Q = \int_0^{h^*} u\,dy^*$$

$$= h^* - \frac{h^*(n_2+n_3)}{(2n_2+n_3)}\frac{\partial p^*}{\partial x^*}\left[\frac{2}{3}h^{*2} + \frac{1}{(2n_2+n_3)}\left\{1 - \frac{\propto h^*\cosh\propto h^*)}{\sin h\propto h^*}\right\}\right] \quad (16)$$

Nowsince the slider bearingangle is very small ,i.e;'m'is very small as the value ofH^*cannot exceed 2. Hence, writing the expansionsfor Sinh($\propto h^*$) Cosh($\propto h^*$)inascending power ofx^* ,we get the simplified formfor$\frac{\partial p^*}{\partial x^*}$as ;

$$\frac{\partial p^*}{\partial x^*} = \frac{3}{(1+mx^*)^2} + \frac{\propto^2}{2} - \frac{3Q}{(1+mx^*)^3} - \frac{Q\propto^2}{2(1+mx^*)} \quad (17)$$

Integrating (17) under the following conditions;

$p^* = p_e$ at $x^* = 0$

$p^* = p_s$ at $x^* = 1$ (18)

We get the expression for thepressure in the region 0≤$x^* \leq 1$ and at the junction respectively ;

$$p^* - p_e = -\frac{3}{m(1+mx^*)} + \frac{\propto^2}{2}x^* + \frac{3Q}{2m(1+mx^*)^2} - \frac{Q}{2m}\log(1+mx^*) \ (19)$$

and

$$p_s - p_e = -\frac{3}{m}\left[\frac{1}{1+m} - 1\right] + \frac{\propto^2}{2} + \frac{3Q}{2m}\left[\frac{1}{(1+m)^2} - 1\right] - \frac{Q}{2m}\log(1+m)(20)$$

Again considering the flow in the region $H \leq x \leq H+B$,we have$h = h_\circ$and $m = 0$.The equation (17) reduces to;

$$\frac{\partial p^*}{\partial x^*} = \left[3 + \frac{\propto^2}{2} - 3Q - Q\frac{\propto^2}{2}\right]x^* + c \ (21)$$

Using the conditions ;

$$p^* = p_e \text{at} x^* = 1 + \frac{B}{H}$$

$$p^* = p_s \text{ at } x^* = 1 \ (22)$$

We get

$$p^* - p_e = \left[3 + \frac{\propto^2}{2} - 3Q - Q\frac{\propto^2}{2}\right]\left[x^* - 1 - \frac{B}{H}\right] (23)$$

and

$$p_s - p_e = \left[3 + \frac{\propto^2}{2} - 3Q - Q\frac{\propto^2}{2}\right]\left[-\frac{B}{H}\right] (24)$$

The pressure at the junctionmust be same throughout ,so equating equation (20) and (24) , we get the equation inQ^* giving the value ofQ^* ,

$$Q^* = \frac{\frac{3}{(1+m)} + \frac{\propto^2}{2} + \left(\frac{\sigma + \propto^2}{2}\right)\frac{B}{H}}{\frac{3}{2}\frac{(m+1)}{(m+1)^2} + \frac{1}{2m}\log(m+1) + \frac{B}{H}\left(\frac{\sigma + \propto^2}{2}\right)} (25)$$

Total normalized capacity is given by ;

$$\overline{w} = \overline{w_1} - \overline{w_2}$$

$$= \int_0^1 (p^* - p_e)dx + \int_0^{1+\frac{B}{H}} (p^* - p_e)\ dx^* \ (26)$$

Substituting value of$p^* - p_e$in the respected region . Integrating equation (2.3.15) we get ;

$$\bar{w} = -\frac{3}{m^2}\log(1+m) + \frac{\propto^2}{4} + \frac{9B^2}{2H^2} + \frac{3\propto^2 B^2}{4H^2} - Q^*\left[\frac{3}{2m^2(1+m)} - \frac{1}{2m}\{2\log(1+m)-1\} - \frac{9B^2}{2H^2} - \frac{3\propto^2 B^2}{4H^2}\right] \quad (27)$$

RESULTS AND CONCLUSION

Thecomplete discussion of results are now presented as follows The parameters to be specified are λ^* ,$\mu_v / \gamma_v, k_v / \gamma_v$ The variation load capacity W for various values of the parameters . Ithas been observed that the load capacityincreaseswith theincrease in the value of coupling constantμ_v / γ_v and k_v / γ_v. Themicro-polar fluidsunder consideration proves to bebetter lubricant forthe slider bearing . Theincrease in the length ofthe flat partalso increase the load capacity .

REFERENCES

1.Eringen, A.C.(1966): "Theory of micro-polar fluids'. Math-Mech. 16, 1-18
2.Pokhriyal S.C. (1998): "Hydrodynamic Lubrication of micro-polar &Yadav A.K. fluid in a composite slider" Proc. National Seminar to 82-90
3.Prakash J. (1967): Magneto hydro magnetic effects in Composite bearing Jour. Lub. Tech. 89(3) , 323
4. Ranuka Raj gopalan (1968): "Some flow problem in micro-polar fluids".Jour Ind. Inst. Sci. Soc. 57-77
5. Rayleigh , L (1912): "Notes on the theory of lubrication" Phil. Mag. Vol. 35
6. Willson , A.J. (1969) : "Basic Flows of micro-polar liquid" Appld. Sci. Res. 20 , 338-355