Stability Analysis of Hydrodynamic Journal Bearing Under Micropolar Lubrication

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ABSTRACT

The lubricant available commercially, behave like non-Newtonian fluids due to the presence of different kind of additives. The characteristics of finite width hydrodynamic journal bearings lubricated with micropolar fluidsare confronted. The modified Reynolds equation is incurred by applying micropolar lubrication theory. The modified Reynold equation is solved for the half Summerfold boundary condition. The stability in term of critical mass and eccentricity is obtained. The results show the comparison of the stability of the Newtonian fluids and the micropolar fluids. Results show that the stability is more if micropolar fluids are used. The microrotation near the surfaces of the bearing enhances the bearing pressure capacity and the stability.

Keywords: ***Micropolar Lubricant, Stability, Short Bearing.***

I INTRODUCTION

In the age of technical development, the market flooded with the engineered lubricant. These lubricants contain suspended additives. Thus the classical continuum theory is unable of calculating proper flow behavior of such fluids. Thisleads to thegeneralization of Reynold equation according to the flow properties of these fluids. A new Reynold equation that takes into account all possible variation in boundary viscosity and microrotation near thesurface is driven [1]. Micropolar fluids obtained from the general microfluidic by imposing the assumption of gyration tensor and microisotropicproperty that still exhibit microstructure. These fluids only exhibit microrotational effects and support surface and body couples [2]. Das S. et al. [3] used first-order perturbation of the film thickness and steady state film pressure, the dynamic characteristics in term of stiffness and damping coefficients; critical mass is obtainedconcerning micropolar property for varying eccentricity ratios and slenderness ratios. Wan Cai et al.[4] applied micropolar lubrication theory on short bearing approximation. The spatial displacement of therotor in horizontal and vertical directions are considered for various nondimensional speed ratios. The stability of the system varies with thenondimensional speed ratios. The rotor center trajectory had undesired vibrations. The center stability is calculated.

Mathematically, for anunstable system, the level of vibration goes to infinity. There is apossible system failure, or system behavior enters nonlinear regime at higher amplitude level, vibration does not reach infinite levels. The

Dynamic instability the amplitude grows instability becomes unbounded with time if linear stability theory holds. The damping and stiffness properties of the lubricant effect the stability of the journal in bearing. In this work the critical mass parameter depends upon the damping and stiffness is calculated for the dynamic stability of the journal. The parameter calculated for both Newtonian and micropolar fluids.

II MATHEMATICAL MODELING OF SHORT HYDRODYNAMIC JOURNAL BEARING

In hydrodynamic journal bearing consist of the journal surrounded by a enveloped called bearing. In Fig. 1 shows the schematicdiagram of the journal bearing.

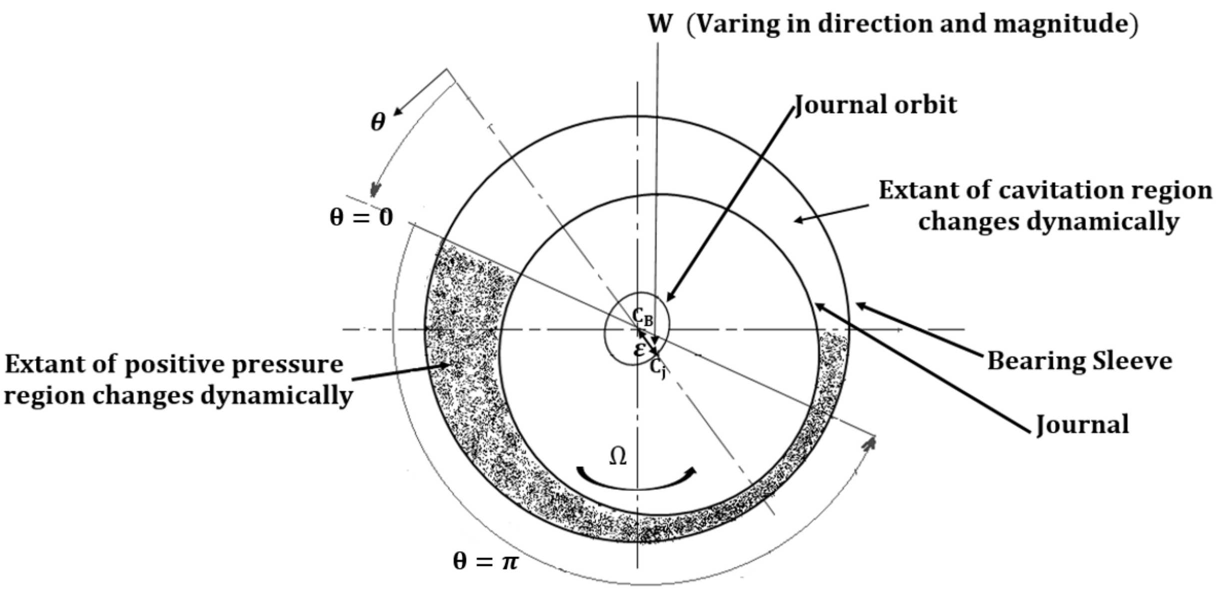


Fig 1 Schematic diagram of hydrodynamic journal bearing

The equation for the critical mass developed by considering the continuum theory of micropolar fluids.

Critical mass is defined by

$$M_I = \left(D_{xx}D_{yy} - D_{xy}D_{yx}\right) \Big/ \left[\frac{(D_{xx}+D_{yy})(K_{xx}K_{yy}-K_{xy}K_{yx})}{K_{xx}D_{yy}+K_{yy}D_{xx}-K_{yx}D_{xy}-K_{xy}D_{yx}} - \frac{K_{yx}D_{xy}+K_{yy}D_{yy}+K_{xx}D_{xx}+K_{xy}D_{yx}}{D_{xx}+D_{yy}}\right] \quad (1)$$

$$M_{II} = \left(D_{xx}D_{yy} - D_{xy}D_{yx}\right) \Big/ K_{xx} + K_{yy} \quad (2)$$

Where, D_{xx}, D_{yy}, $D_{yx,}$and $D_{xy}$are the damping coefficient of the micropolar fluid in thehorizontal and vertical axis direction and there coupled damping in both the direction. The K_{xx}, K_{yy}, $K_{yx,}$and $K_{xy}$are the stiffness coefficient in the horizontal and vertical axis direction.

$M_{critical}$ = min (M_I or M_{II}) When $K_{xx} + K_{yy} < 0$

= min (M_I) When $K_{xx} + K_{yy} > 0$

The values of the stiffness and damping coefficient are depended upon the eccentricity ε.

The eccentricity defined as

$$\varepsilon = C_B - C_j \qquad (3)$$

Where $C_B$and C_j are bearing center and journal centers respectively.

III RESULT AND DISCUSSION

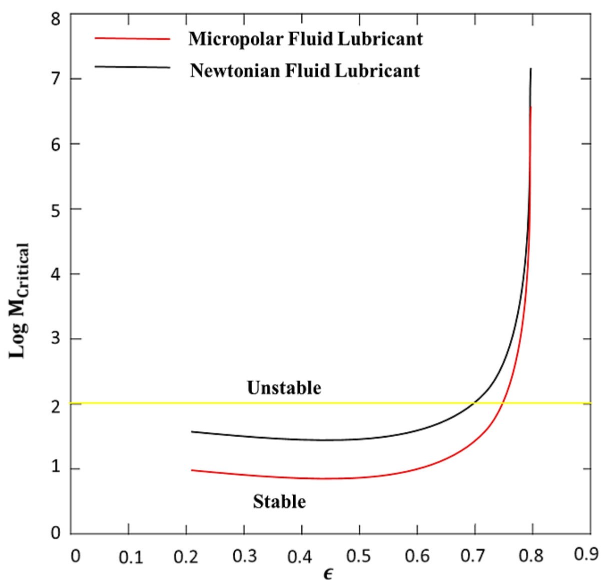
For solving the above equation, the advanced numerical methods are employed, and the MatLab is used for the getting the results. Two cases are discussed here for different short bearing dimension. The above equation isnondimensionalized to make the computation easier. The equation is solved by forwarding difference method. The step size of 0.1. Used and the length of iteration is thelength of the matrix of meshes.

CASE I

The bearing geometrical parameters for input are considered the$l=3.5$ nondimensional characteristic length of the bearing. Viscosity is taken for Newtonian, and the micropolar fluid for the microstructural properties nearly nondimensional viscosity for the micropolar fluid is 0.3. The width to diameter ratio of the bearing is taken as 1 for thefinite and short bearing. $N^2=0.577$ called coupling number. Coupled the viscosity property of Newtonian and micropolar fluids. The logarithmic critical mass is calculated for the different eccentricity ratios. Fig. 2 is showing the variation of the logarithm critical mass with eccentricity for the half Summerfold boundary condition. In Fig. 2. The yellow line shows thethreshold limit of thestable condition to the unstable condition from the results are showing that the at lower eccentricity values the value of critical mass for the Newtonian and micropolar fluids are much lower than the instability threshold. After the value of eccentricity increases from more than 0.6 the value of critical mass parameter increases rapidly and maximum between 0.7 to 0.8 eccentricity value. From the results under micropolar lubrication, the bearing provides more stability in comparison of the Newtonian lubrication.

CASE II

The bearing geometrical parameters for input are considered the $l=3.5$ nondimensional characteristic length of the bearing. Viscosity is taken for Newtonian, and the micropolar fluid for the microstructural properties nearly nondimensional viscosity for the micropolar fluid is 0.3. The width to diameter ratio of the bearing taken as π/10 for the finite and short bearing. $N^2=0.577$ called coupling number. Coupled the viscosity property of Newtonian and micropolar fluids.



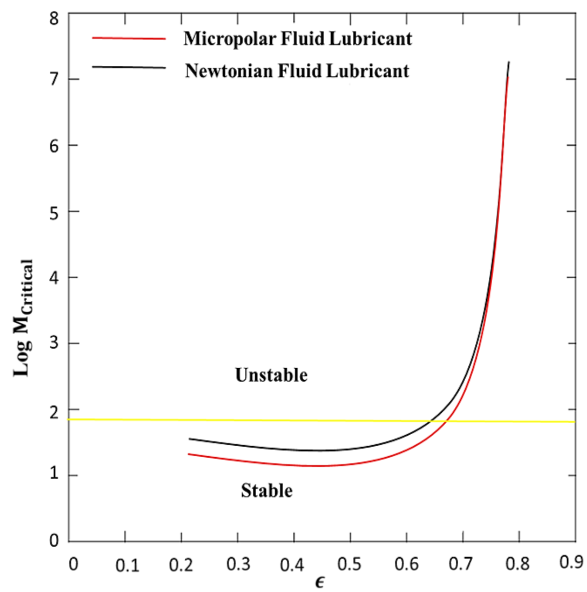


Fig. 2 **Fig. 3**

Fig. 2 Critical mass V/S eccentricity for the finite length short bearing of slenderness ratio of 1

Fig. 3. Critical mass V/S eccentricity for the finite length short bearing of slenderness ratio of π/10

The logarithmic critical mass is calculated for the different eccentricity ratios. Fig. 3. is showing the variation of the logarithm critical mass with eccentricity for the half Summerfold boundary condition. In Fig. 3. The yellow line shows thethreshold limit of thestable condition to the unstable condition from the results are showing that the at lower eccentricity values the value of critical mass for the Newtonian and micropolar fluids are much lower than the instability threshold. After the value of eccentricity increases from more than 0.6 the value of critical mass parameter increases rapidly and maximum between 0.7 to 0.8 eccentricity value. From the results under micropolar lubrication, the bearing provides more stability in comparison of the Newtonian lubrication.

IV CONCLUSION

The stability is the main issue related to the journal in the bearing. The instability in the rotor causes the failure of the structure and the system. The analysis of the bearing done for the micropolar and Newtonian fluid lubrication and following conclusion is drawn:

The stability is dependent upon the eccentricity of the journal under load.

The stability is also dependent upon the damping and the stiffness properties of the lubricant in horizontal and the vertical direction of the bearing.

The change in the dimension of the bearing is also crucial for the stability of the bearing.

The micropolar fluid lubricant is more stable than the Newtonian fluid lubricant in the hydrodynamic journal bearing.

The future work can be conductedfor load-bearing capacity of the bearing.

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