NUMERICAL SOLUTIONS OF SOME BEARING PROBLEMS USING ROUGHNESS AND MAGNETIC FLUID

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Content

1. Abstract

Due to speedy industrial development there has been a spurt in machines and bearings are the most noticeable constituents of today's machines. When the parts of the machine components move relatively in contact with each other, friction and wear are caused. While friction consumes and wastes energy, wear causes loss of material. Thus, the life of the machine is significantly reduced. To reduce this outcome we insert matters in the bearing called lubricants. So, the study of friction, wear, lubrication, design of bearings, science of interacting surface in relative motion is named Tribology.

Tribology gives the guidelines to the difficult representation of wear and friction for understanding such phenomena. We create mathematical model and its numerical analysis supportive to us in the wake of statistical development. The prediction of lubricating film characteristics is the essential factor from an application approach.

The bearing surfaces tend to be rough by several ways, normally by machining treatment and coating process. The effect of surface roughness plays important role in the progress of study on Tribology. The roughness gives the adverse effect in the bearing performance. To decrease this effect, the use of magnetic fluid as a lubricant has been extensively used.

In industry, many production plants are constantly in working process. So heat is produced. Due to heat the conventional lubricant melts. So, to reduce this problem we use magnetic fluid and considering thermal effect.

Porous medium is important part of bearing system problems in Tribology. Using porous media the bearing is manufactured to enhance the performance and its life period as well.

An effort has been made to evaluate the extent to which a magnetic fluid can go in reducing the adverse effect of roughness induced by friction and wear. Thus, efforts have been afoot to analyze the effect of roughness and magnetic fluid on exponential slider bearing, short bearing and truncated conical plate. The method is related with the stochastically averaged Reynolds' type equation and its solution by using suitable boundary conditions to obtain the pressure distribution. Then we calculate the load carrying capacity numerically and graphically present the results.

The graphical results show the load carrying capacity with respect to different parameters of roughness and magnetization. The results indicate that the load carrying capacity decreases because of transverse surface roughness and the magnetic fluid lubrication minimize the adverse effect. Also help of the porous medium the bearing life period longer.

2. Brief description on the state of the art of the research topic

There is a long history on Tribology. In 15th century, Leonardo da' Vinci developed many of the basic rules of friction the relationship between normal force and frictional force (Dowson, 1979). Even the ancient civilizations dealt with low frictional surfaces and developed bearings.

Tribology deals with the study of (1) the characteristic of film of intervening material between contacting bodies and (2) the consequences of either film failure or absence of a film which are usually manifested by severe friction and wear.

Reynolds (1886) verified that the produced hydrodynamic pressure of the lubricant between sliding surfaces was acceptable to prevent contact between surfaces and therefore friction and wear even at very low sliding speeds. The roughness has gained much attention after the associated stochastic concept development. The stochastic Reynolds' equation was derived by Christensen and Tonder (1969a, 1969b, 1970) governing the mean pressure in bearing having longitudinal and transverse roughness. Berthe and Godet (1974) studied a more general form of Reynolds' equation on roughness.

Christensen and Tonder's method molded the base of the analysis to study the effect of surface roughness in number of investigations by Patir and Change (1978), Prakash and Tiwari (1982), Guha (1993), Gupta and Deheri (1996), Andharia et al.(2001).

Magnetic fluid flow is administered by the model of Neuringer Rosensweig (1964). Beavers Joseph's (1967) slip model accounts for the impact of slip velocity. Tipei (1962) model is used for thermal effect. Using the models valuable works has been done by numerous authors like Siddangouda et al. (2013), Patel et al. (2016).

Bhat (1982) considered the oil based lubrication of an exponential permeable slider bearing and inferred that utilization of porous matrix diminished the load limit and friction force on slider bearing. Cameron (1987) proposed the shape which was approximately near to the shape of an exponential form of the slider. Patel et al. (2018) investigated the ferrofluid lubrication of a journal bearing considering the thermal effect. The load bearing capacity got reduced due to thermal effect. Andharia and Deheri (2011) discussed the consolidated impact of magnetic fluid lubrication and longitudinal roughness on the squeeze film lubrication between truncated conical plates. Patel and Deheri (2013) analyzed the effect of slip velocity on short bearing.

First of all, the study dealing with the performance of a rough short bearing considering thermal effect and slip velocity. It was noticed that the situation remained better in the case of negatively skewed roughness. But the overall situation was comparatively better when negative value of variance occurred.

Combined impact of roughness and slip velocity of the porous exponential slider bearing was analyzed in presence of magnetic fluid. Associated stochastically averaged Reynolds' type equation was solved for the pressure distribution. The load carrying capacity was calculated. It was noticed that the magnetization went to a limited extent to counter the effect of slip velocity and roughness.

To extend the above investigation in the presence of thermal effect, the model of Tipei has been adopted. To overcome the thermal effect porosity was add at reduced level.

An investigation was launched in to the magnetic fluid lubrication of a double layered porous squeeze film in longitudinally rough truncated conical plates considering slip velocity. The longitudinally roughness was modeled in the light of the stochastic method of Christensen and Tonder. For any type of improved performance smaller values of porosity and slip velocity were founded to be conducive.

3. Definition of problem

The mathematical model is created on hydrodynamic lubrication. The problem relates with bearing which is a part of machine elements and mainly we calculate the load carrying capacity. To some extent bearing surfaces are always rough. Due to rough surface the wear and friction occur. So we use lubricant. In some machinery, due to constant operational process thermal effect occurs. So, here the magnetic fluid is used instead of conventional lubricant. For the self-lubrication the porous medium is used.

In numerous engineering applications like in gears, machine tools, clutch plates, sliding contact bearing etc. the magnetic fluid is applied to minimize the effect of roughness and porosity.

The model governing the mean pressure is known as averaged Reynolds' type equation. Solving that differential equation one can find pressure and afterwards the load carrying capacity. In entire study Simpson 1/3rd rule applied for integration.

4. Objectives

- Objective is to minimize the adverse impact of roughness, porosity and slip velocity by lubricating the system with a magnetic fluid. For this purpose, short bearing, exponential slider bearing, truncated conical plates are subjected to investigation.
- Even the thermal effect was formed to be reduced due to the presence of magnetic fluid.

5. Scope of work

The research work states that investigations can be modified and developed in the following directions.

- Here the mathematical model is presented in one dimensional that can be extended to two dimensional models.
- Longitudinal or transverse roughness can be considered for analyzing the performance for various kinds of bearing systems such as triangular bearing, elliptical bearing and rectangular bearing.
- The effect of temperature can be measured and analyzed, because the change in temperature can affect the viscosity of the lubricant. In the bearing system like truncated conical plates, inclined plane slider, elliptic plates and journal bearing.
- Also, Shliomis and Jenkin's model can be considered for magnetic fluid lubrication.

6. Original contribution by the thesis

The original contribution by the thesis is adapted mathematical model which analyze:

- The effect of transverse roughness and magnetic fluid on the performance of porous exponential slider bearing considering slip velocity. This study has been extended to consider thermal effect.
- The effect of magnetic fluid lubrication of a double layered porous squeeze film of truncated conical plates with slip velocity in presence of longitudinally roughness.
- The effect of slip velocity and roughness on the performance of a short bearing in presence of thermal effect.

The results of such bearings geometry problems are obtained graphically and measures have been provided to improve the bearing design.

7. Methodology of Research and Results

In the mathematical model below assumptions were considered:

- There are no extra fields of forces acting on the lubricant i.e. Body forces are neglected.
- The Reynolds hydrodynamic lubrication theory concept is applicable to lubrication in the bearing system.
- The bearing dimensions are assumed to be constant for width, length, axial height, outer and inner diameter and clearance.
- The flow is assumed to be steady in horizontal direction and surface roughness is considered either transverse or longitudinal.

In the research work one dimensional problem is considered. In this problem magnetic parameter, various roughness parameters like variance, standard deviation and skewness are taken. The roughness pattern parameters for transverse and longitudinal of the rough surface are introduced at different stages and then solved the one dimensional differential equation for the mean pressure at the contact zone of the bearing system with suitable boundary conditions. The load carrying capacity is obtained.

Throughout the work, the integrals occurring in the calculation is carried out by Simpson's $1/3^{rd}$ rule. The results of load carrying capacity and mutual relations between two parameters are shown graphically by the help of numerical data. The load carrying capacity is obtained for various film shapes like exponential slider bearing, truncated conical plates and short bearing.

8. Achievements with respect to objectives

The objective was in fact to enhance the performance of the bearing system in the presence of several parameters affecting the system adversely to a limited extent. The objective was realized by the use of magnetic fluid lubrication.

This is highly unlikely in the area of conventional lubrication. Even when no flow occurs, there is same amount of load supported by the system.

9. Conclusion

The investigation for rough short bearing suggests that the transverse roughness and slip velocity induce an adverse effect on load bearing capacity. The situation improves when negative values of skewness are involved. The impact of magnetic and roughness parameters on the pressure and load carrying capacity for a rough porous exponential slider bearing with slip velocity have been analyzed. It is observed that the load carrying capacity gets increased by decreasing the value of the transverse roughness and increasing the value of the longitudinal roughness. The bearing system remains a little better in case of negative value of skewed roughness. The adverse effect of roughness augments when moderate to higher values of porosity are involved. If there is no flow in such type of bearing systems sustains certain amount of load, which does not happen in the case of conventional lubricant based bearing system. When the thermal effect is at reduced level magnetization helps in countering the effect of surface roughness. The performance of the bearing system remains a little better in case, negative values of variance are involved. In the truncated conical plates the longitudinal roughness also helps to overcome the effect of slip velocity up to certain extent. The positive effect of double layered in conjunction with magnetic fluid lubrication presents a better picture. It is also clear that the performance and life of the bearing system can be enhanced by choosing proper bearing geometry.

10. List of Publications

1. S. A. Patel, A. R. Patel and G. M. Deheri, Combined impact of roughness and slip velocity on the ferrofluid lubrication of the porous exponential slider bearing,

International Journal of Advanced Research in Engineering and Technology. 9(3), 2018, pp. 221-232.

2. S. A. Patel, A. R. Patel and G. M. Deheri, Magnetic fluid lubrication of a double layered porous squeeze film in longitudinally rough truncated conical plates considering slip velocity, Journal of Emerging Technologies and Innovative Research. 5(7), 2018, pp. 330-335.
3. S. A. Patel, A. R. Patel and G. M. Deheri, A study of thermal effect on the ferrofluid lubrication of a rough porous exponential slider bearing considering slip velocity, International Journal Of Applied Engineering Research.14(10), 2019, pp. 2408-2416.
4. S. A. Patel, A. R. Patel and G. M. Deheri, Performance of a rough short porous bearing considering thermal effect and slip velocity, International Journal of Engineering Technology and Computer Research. 7(4), 2019, pp. 18-23.

Paper Presented in Conference

1. S. A. Patel, A. R. Patel and G. M. Deheri, Magnetic fluid lubrication of a double layered porous squeeze film in longitudinally rough truncated conical plates considering slip velocity, international Conference on Advances in Engineering and Technology AIET-2018, Silver oak Group of Institutes, Ahmedabad,Gujarat.
2. S. A. Patel, A. R. Patel and G. M. Deheri, A study of thermal effect on the ferrofluid lubrication of A rough porous exponential slider bearing considering slip velocity, Prof. P.C. Vaidya National Conference on Mathematical Sciences, GGM, Dec-2018, St. Xavier's College, Ahmedabad,Gujarat.

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