The present thesis deals with the theoretical study of lubrication characteristics of bearings with non-Newtonian fluids. In these theoretical investigations of the problems, the Mathematical models have been developed for better understanding of the performance of various bearings lubricated with non-Newtonian fluids.

Tribology is an interesting subject and is useful in understanding the friction, wear, lubrication and the invention of devices. To accommodate them, knowledge in all areas of Tribology has expanded tremendously because of enormous industrial growth. Tribology is crucial to modern machinery which uses sliding and rolling surfaces.

Lubricant is a substance used between sliding surfaces to reduce wear and friction. The use of lubricant is an ancient practice, and Egyptian pictures dating back 4000 years show the application of lubricants to reduce the friction involved in changing heavy monuments. In modern practice, the main concern is to reduce the wear that accompanies sliding and at the same time to design lubrication systems that will operate for long periods without inspection of maintenance. The process of reducing wear and heat between contacting surfaces in relative motion is known as lubrication theory.

Bearings in nuclear and space engineering applications use liquid metal lubricants because conventional lubricants are not suitable for the operating temperatures. Bearing find their applications in several mechanical components, which reduce the frictional losses between two rotating or sliding mechanical parts. To understand the functioning of these machine components, the pressure distributions velocities must be known. The additives are frequently used in lubricating fluids, which make them non-Newtonian. The use of non-Newtonian fluid as lubricants has become more important with the development of modern industrial materials, since the Newtonian fluid constitutive
approximation is not found to be satisfactory engineering approach for many practical lubrication applications. Experimental results suggest that the addition of small amount of long chain polymer solution to a Newtonian lubricant gives the most desirable lubricant. The classical continuum theory fails to explain the motion of fluids that contain coar structure and fibres such as colloidal fluids, liquid crystals and fluids containing additives.

Studies of squeeze-film characteristics play an important role in engineering science and industrial application such as skeletal joints, bio-lubrication, gears, bearings, machine elements, rolling elements, and engine components. Traditionally analysis of squeeze-film behaviour focus upon the mechanism lubricated with a non-conducting viscous lubricant. Many researches concerning with squeeze-film have been presented for rectangular plates, the parallel surfaces, the curved annular plates, the spherical bodies and the system between a sphere and a flat surface. With the development of modern machine elements the use of an electrically conducting fluid as the lubricant to avoid the viscosity variation with temperature has been emphasized. The behaviour of fluids with microstructure called micro-fluids their motion, balance equation, entropy, constitutive equations and finally partial differential equations of motion have been presented by Eringen (1964).

Eringen’s micropolar fluid theory has gained considerable attention in recent years, as this theory has unique feature which is suitable for modelling a wide variety of fluid flow problems. Eringen (1966) proposed the theory of micropolar fluids for the case where only micro-rotational effects and micro-rotational inertia exists. Several investigators have used this micropolar fluid model for the study of various bearing systems by Naduvinamani and Huggi (2006), Naduvinamani and Savitramma (2014). Hence in the present thesis, the studies of lubrication characteristics of bearings lubricated with non-Newtonian fluids have been presented.
The variation in viscosity with temperature is important in many practical applications where lubricants are required to function over a wide range of temperature. There is no fundamental mathematical relationship that will accurately predict the variation in the viscosity of oil with temperature. The viscosity of lubricants increases remarkably with increasing pressure. As the pressure existing in the lubricant film of hydrodynamic bearings, the viscosity of the lubricant may vary many times greater than its viscosity as measured at atmospheric pressure. This property of lubricants undoubtedly has an influence on bearing performance characteristics such as load-carrying capacity, friction, and of temperature rise. Several investigators have used this viscosity variation for the study of various bearing systems Gould, P. (1971), Lu, and Lin, (2007), Lin, Chu, and Liang, (2013), Reddy, Reddy, and Prasad, (2000), Lin, Chu, and Liang, (2013).

The Rabinowitsch fluid (cubic equation) model has been introduced to study the non-linear relationship between shear stress and shear strain rate. This cubic equation was first suggested by Rabinowitsch (1929) and has been used in another connection by Rotem and Shinnur (1961). Hence, in the present thesis the performance of inclined stepped composite bearings lubricated with Rabinowitsch fluid has been studied. Several investigators have used this fluid model for the study of various bearing systems Singh, and Gupta, (2012), and Lin, (2012).

In recent years, a considerable amount of research has been devoted to the study of the effect of surface roughness by Christensen, H. (1969), Kudenatti, Basti, and Bujurke, (2012), Walicka, (2012), Sayles, Thomas, Anderson, Haslock, and Unsworth, (1979) on hydrodynamic lubrication of bearings, mainly because, in industrial practice, most of the bearing surfaces are rough. The aspect ratio and the absolute height of the asperities and valleys observed under microscope vary greatly, depending on material properties and on the method of surface preparation. Hence, a part of the thesis is devoted
for the study of effect of surface roughness in the characteristics of squeeze film bearings lubricated with non-Newtonian fluids.

This thesis is organized into seven chapters.

Chapter I is of introductory in nature and contains motivation for the study, introduction to the principles of lubrication theory and classification of fluids. The basic equations and the detailed literature survey for the lubrication of bearings with non-Newtonian fluids viz: micropolar fluids, and Rabinowitsch fluids is presented.

In Chapter II the effect of the viscosity variation on the squeeze film performance of a short journal bearings lubricated with micropolar fluid is presented. The modified Reynolds equation accounting for the viscosity variation in micropolar fluid is mathematically derived. To obtain a closed form solution, the short bearing approximation under constant load is considered. The modified Reynolds equation is solved for the fluid film pressure and then the bearing characteristics, such as the load carrying capacity and the squeeze film time are obtained. According to the results evaluated, the micropolar fluid as a lubricant improves the squeeze film characteristics and results in a longer bearing life. Whereas the viscosity variation factor decreases the load carrying capacity and squeeze film time. The results are compared with that of the corresponding Newtonian case.

Chapter III deals with the combined effects of viscosity variation and surface roughness on the squeeze film performance of journal bearings lubricated with micropolar fluids is made. The modified averaged Reynolds equation for micropolar fluids accounting for the randomized surface roughness structure and variation of viscosity is mathematically derived. The Christensen stochastic theory of hydrodynamic lubrication of rough surfaces is used to study the effect of two types of one dimensional surface roughness patterns on the squeeze film characteristics of a journal bearing with
micropolar fluid. Closed form expressions for the mean pressure load carrying capacity are obtained for the infinitely short journal bearing. It is observed that, the transverse surface roughness pattern improves the squeeze film characteristics where as the adverse effects are observed for the one dimensional longitudinal surface roughness pattern.

Chapter IV deals with the effect of pressure-dependent viscosity variation on the squeeze film characteristics between convex curved plates of a cosine form is presented. Micropolar fluid theory which is a possible non Newtonian model of a suspension of rigid particle additives is applied to the study of the lubrication of Cosine form convex curved plates. The modified Reynolds equation is solved for the fluid film pressure by considering the exponential relationship in the viscosity variation. For iso-viscous lubricants, the effects of pressure dependent viscosities signify an increase in the squeeze film pressure, the load carrying capacity and the elapsed time. The result obtained in this chapter provides useful information in designing the mechanisms of squeeze film plates for engineering application.

Chapter V deals with the combined effects of surface roughness and viscosity variation on the squeeze film characteristics of micropolar fluid in convex curved plates are analytically studied. The variation in viscosity along the film thickness is considered. The modified Reynolds type equation for surface roughness has been derived on the basis of Eringen’s micropolar fluid theory. For iso-viscous lubricants, the effects pressure dependent viscosities signify an increase in the squeeze film pressure, the load capacity which improved the performance of the bearing. The presence of transverse surface roughness pattern improves the squeeze film characteristics as compare to longitudinal surface roughness pattern.

In Chapter VI a theoretical analysis on the squeeze film characteristics between circular stepped plates lubricated with Rabinowitsch fluid is presented. By using
Rabinowitsch fluid model, the modified Reynolds type equation is derived to study the dilatant and pseudoplastic nature of the fluid in comparison with Newtonian fluid. The closed form solution is obtained by using perturbation method. According to the results obtained, the load-carrying capacity and squeeze film time increases for dilatant fluids as compared to the corresponding Newtonian fluids whereas the reverse trend is observed for pseudoplastic fluids. Further, it is observed that the response time decreases as the step height increases.

In Chapter VII, a theoretical analysis of the effects of micropolar on the squeeze film lubrication between parallel stepped plates is presented. The modified Reynolds equation accounting for the viscosity variation in micropolar fluid is mathematically derived. According to the results obtained, the influence of micropolar enhances the squeeze film pressure, load carrying capacity and decreases the response time as compared to the classical Newtonian lubricant case. The load carrying capacity decreases as the step height increases.