Numerous theoretical and experimental works have been done on the subject of Fluid Film Lubrication. Various mathematical models involving a number of bearing and slider shapes and lubricants as Newtonian fluids, non-Newtonian fluids or even air have been considered and the results have been verified experimentally.

With the development of instrumental design, porous metal bearings are recently widely used because of their simple structure, low cost and self-lubrication characteristics. Further, to minimise the effect of fatigue, friction, wear, erosion, electrical and thermal effects on contacts; metallic bearing surfaces are to be coated by suitable layers of compounds and a few bearings are thereby required to be considered as porous bearings.

In order to prevent viscosity variation with temperature change, in recent years, lubricating oils with sufficient additives of high-molecular-weight polymers as a viscosity index improver are often used. These even contain magnetic suspensions in high energy efficiency systems. But with the introduction of polymers or suspensions, the lubricants behave as non-Newtonian fluids. These non-Newtonian lubricants can be theoretically analysed based specially on (i) Power law fluid model, (ii) Micropolar fluid model, (iii) Viscoelastic fluid model, (v) Magnetic fluid model, etc.
(1) In power law fluid model, a constitutive equation in modified form is

\[ T_{1j} = 2\mu \left\{ \left( |2e_{1k}e_{k1}| \right)^{\frac{1}{3}} \right\} n - 1 e_{1j} \]  

where \( n \) is power index, \( T_{1j} \) is the stress tensor and \( e_{1j} \) is the strain tensor.

(ii) One of the specialized micropolar fluid theories is the couple stress fluid theory, proposed by Stokes (1966), whose constitutive equations are given by

\[ T_{1j} = \left( - p + \lambda \nu_{k,k} \right) \delta_{1j} + \mu (v_{i,j} + v_{j,i}) - \frac{\rho}{2} e_{1jk} e_{k} + \nu \nu (v_{i,j} - v_{j,i}) \]  

\[ M_{1j} = 2\eta e_{1j,\alpha} v_{k,\alpha} + 2\eta' e_{1j,\beta} v_{\beta,\alpha} \]  

and \[ \rho g_{1} + e_{1jk} T_{jk} + M_{j},j = 0 \]  

where \( T_{1j} \) and \( M_{1j} \) are respectively stress and couple stress tensors, \( g_{1} \) is body couple per unit mass, \( \mu \), \( \lambda \) are classical viscosity coefficients, and \( \eta \), \( \eta' \), are new material constants of the couple stress fluid.

(iii) Out of different visco-elastic fluid theories, second order Rivlin-Ericksen (1955) fluid model is in great use in the fluid film lubrication. The constitutive equation of this model can be written as

\[ T = pI + \mu A_{1} + \alpha_{1} A_{2} + \alpha_{2} A_{1}^{2} \]  

where \( T \) is the stress, \( A_{1} \) and \( A_{2} \) are symmetric parts of
velocity and acceleration gradients respectively.

(iv) The couple stress fluid model can also be applied to analyse the properties of polar magnetic fluids, where the body force \( b_1 \) in the equation of motion,

\[
\rho \dot{v}_1 = \rho b_1 + T_{j1,j}
\]

is \( \sigma(\vec{E} + \vec{v} \times \vec{B}) \times \vec{B} \) due to the electric and magnetic fields \( \vec{E} \) and \( \vec{B} \) respectively.

To meet the increasing demand for successful lubrication in the modern instrumentation world, research and development of the lubrication aspects offers a great scope and it needs both more theoretical and experimental development in fluid film lubrication.

Keeping this in mind we have worked out seven steady and unsteady problems theoretically using constitutive equations (1) to (6). Wherever possible we have compared our results with experimental investigations by other authors.

In the first chapter, we have given an introduction on the subject and on the relevant areas. The mathematical models of slider bearings and various fluids, and the scope of the thesis has been outlined.

The Chapter II deals with the "Analysis of porous step bearing". Bujurke et. al. (1991) discussed the characteristics of squeeze film porous step bearing with couple stress fluid (equns. (2) - (4) as lubricant, but the existing solu-
tions for pressure are found not to satisfy the boundary conditions. In this chapter the correct solutions for pressure are obtained and a significant derivation is obtained from the existing works for values of positions of maximum pressure, and load capacity. The analysis reveals a significant deviation from Bujurke's results.

In the third chapter, "Analysis of unsteady squeezing porous step bearing" has been considered. Considering the lubricant to be a couple stress fluid, a theoretical study on unsteady squeezing mode of an infinitely long porous slider bearing is presented. Analytical expressions for pressure gradient is derived in general form and as a particular case, periodic oscillation along with steady squeezing of a step bearing is considered. The analysis gives a significant effect of couple stress along with periodic oscillation.

In Chapter IV, we have considered "A general discussion on porous bearing lubricated by couple stress fluid". A theoretical study is presented for infinitely long porous slider bearings in general form. In this chapter, analytical expressions for load capacity, frictional force and centre of pressure are derived and a comparative study have been made for six different form of bearings. The analysis concludes that a wavy slider bearing lubricated with couple stress fluid may withstand maximum load bearing capacity.

In the fifth chapter, we have developed "Effect of
sliding velocity on synovial joint". An analytical study of synovial joint lubricated by a second order fluid is considered in general form of film thickness. This investigation analyse the effect of sliding velocity on load capacity and in particular, approximate results of single porous step slider bearing as a modified synovial joint have been obtained using Darcy's flow of liquid in porous region. Approximate expressions for dimensionless pressure, load capacity and response time have been obtained. The analysis indicates significant effect of sliding velocity on synovial joints.

In Chapter VI, we have considered "Porous slider bearing lubricated with couple stress MHD fluids". A theoretical study is presented for infinitely long porous slider bearing in general form, considering the lubricant to be an electrically conducting couple stress fluid in presence of uniform magnetic field. Deriving analytical expressions for pressure, load capacity, centre of pressure and frictional force, a comparative study for three different bearings are presented. The inlet film thickness for maximum load capacity in the case of inclined slider bearing is obtained and it is found to depend on both couple stress parameter and magnetic field intensity.

In the seventh chapter, we have considered "Couple stress fluid model incorporated into elastohydrodynamic lubrication theory". This chapter mainly deals with the theoretical value of least central film thickness on rolling and sliding
surfaces in terms of equivalent radius of a cylinder moving over a moving plane. Corresponding film shapes and pressure distributions are also calculated numerically and presented graphically. The present theoretical consideration with couple stress fluid indicated increase of least film thickness in conformity with the experimental observations with polymer thickened lubricants.

In chapter eight, we have considered "Power law fluid model incorporated into EHL theory of line contact". An algorithm is developed for the study of the infinitely long slider bearing in general form, and as a particular case a theoretical study on EHL is presented for different values of power law exponent. The effect of power law exponent on the least central film thickness, minimum film thickness and load capacity, and effects of rolling and sliding velocities of contact surfaces are analysed. A few film shapes and pressure distributions are also calculated numerically and presented graphically. A number of observations obtained here are in good agreement with the experimental results. The theoretical observations suggest the behaviour of a lubricant as a pseudo-plastic lubricant in the case of slow motion of surfaces under heavy load.

The thesis is appended with a wide range of bibliography on the subjects dealt in various Chapters.