	Preface	xiii		
	Acknow	xv		
	List of	xvii		
Chapter 1:	Introd	luction	1	
	1.1	History of Lubrication	1	
	1.2	History of Friction and Wear	3	
	1.3	Regimes of Lubrication	3	
	1.4	Hydrodynamic Lubrication	5	
	1.5	Hydrostatic or Externally Pressurized Lubrication	6	
	1.6	Elastohydrodynamic Lubrication	7	
	1.7	Squeeze Film Lubrication	8	
	1.8	Partial and Mixed Lubrication	9	
	1.9	Boundary Lubrication and Lubrication by Solid Lubricants	10	
	1.10	Micro and Nano Tribology	11	
	1.11	Biotribology	13	
	1.12	Tribology and Economic Gain	13	
	1.13	Summary	14	
	References			
Chapter 2: Vis		osity and Rheology of Lubricants	16	
	2.1	Introduction	16	
	2.2	Newtonian Behavior of Fluids	16	
	2.3	Non-Newtonian Fluids	17	
	2.4	Units of Viscosity	20	
	2.5	Pressure-Temperature Effects on Viscosity	20	
	2.6	Viscosity Grades of Oils	24	

			Contents
	2.7	Viscosity Index	24
	2.8	Viscosity Measurement	25
	2.9	Chemistry of Lubricants	33
	Referen	nces	34
Chapter 3:	Mech	36	
	3.1	Introduction	36
	3.2	Momentum Equations	36
	3.3	Stress-Strain Relationship for Fluids	37
	3.4	Navier-Stokes Equations	39
	3.5	Continuity Equation	39
	3.6	Energy Equation	41
	3.7	Reynolds Equation	43
	3.8	Lubricant Flow	46
	3.9	Shear Forces	47
	3.10	Reynolds Equation Assumptions Justified	48
	3.11	Derivation of Thermal Reynolds Equation	49
	3.12	Reynolds Equation for Lubrication with Non-Newtonian Fluids	52
	3.13	Reynolds Equation for Power Law Fluids	56
	3.14	Examples of Slow Viscous Flow	60
	Examp	<del>-</del>	64
	Proble	68	
	Refere	nces	69
Chapter 4:	Hydr	odynamic Lubrication	70
	4.1	Introduction	70
	4.2	Hydrodynamic Journal Bearings	70
	4.3	Long Bearing Solution	73
	4.4	Boundary Conditions	80
	4.5	Short Bearing Solution	82
	4.6	Oil Flow	84
	4.7	Hydrodynamic Thrust Bearings	88
	Exam		94
	Proble		97
	Refere	nces	98

## Contents

Chapter 5:	Finite Bearings	100
	5.1 Introduction	100
	5.2 Analytical Solution	100
	5.3 Numerical Solution	102
	5.4 Cavitation and Cavitation Boundary Conditions	117
	Examples	119
	References	120
Chapter 6:	Thermohydrodynamic Analysis	
	of Fluid Film Bearings	121
	6.1 Introduction	121
	6.2 Thermal Analysis of Sector-Shaped Tilting Pad Thrust Bearings	121
	6.3 Thermohydrodynamic Analysis of Journal Bearings	129
	6.4 Solution Procedure	133
	6.5 Thermoelastic Deformation of Shaft–Bush System Using Finite Element Method	139
	6.6 Adiabatic Solution for Thermohydrodynamic Lubrication Problem in Journal Bearing	142
	6.7 Thermohydrodynamic Analysis Using Lobatto Quadrature Method	144
	References	152
	Appendix 6.1	154
Chapter 7:	Design of Hydrodynamic Bearings	156
	7.1 Introduction	156
	7.2 Practical Considerations	156
	7.3 Bearing Materials	158
	7.4 Bearing Design	160
	References	162
Chapter 8:	Dynamics of Fluid Film Bearings	163
***	8.1 Introduction	163
	8.2 Derivation of Reynolds Equation for Journal Bearing under Dynamic Condition	164

		Со	ntents		
	8.3	Dynamics of Rotor-Bearings Systems	165		
	8.4	Stiffness and Damping Coefficients	166		
	8.5	Stability of Rigid Rotors Supported on Fluid			
		Film Bearings	175		
	8.6	Rotor Instability: Nonlinear Analysis	184		
	8.7	Dynamically Loaded Bearings: Nonlinear Analysis	186		
	8.8	Squeeze Film Lubrication	187		
	8.9	Squeeze Film Damper	194		
	Proble	ms	196		
	Refere	nces	197		
Chapter 9:	Exte	rnally Pressurized Lubrication	199		
	9.1	Introduction	199		
	9.2	Circular Step Externally Pressurized Thrust Bearing	200		
	9.3	Externally Pressurized Multirecess Journal Bearing with Short Sills	207		
	9.4	Multirecess Externally Pressurized Journal Bearings with Large Sill Dimensions	212		
	9.5	A General Analysis of Dynamic Characteristics of Multirecess Externally Pressurized Journal Bearings with Large Sills	229		
	9.6	Analysis of Fluid Seals	242		
	Exam,	•	252		
	Problems				
	Refere		255 255		
Chapter 10:	Fluid	l Inertia Effects and Turbulence			
omptor 10.	in Fluid Film Lubrication				
	10.3	1 Fluid Inertia Effects in Lubrication	259		
	10.2	2 Fluid Inertia Effect in Thrust Bearings	260		
	10.3	Performance of Circular Step Hydrostatic Thrust Bearing Including Centrifugal Inertia and Using Bubbly Lubricant	263		
	10.	•	273		
	10.	5 Influence of Temporal Inertia on the Performance of Journal Bearings	280		
	10.0	•	283		

## Contents

	10.7	Theory of Turbulent Lubrication	288		
	10.8	Fluctuations and Average Values in Turbulent Flow	289		
	10.9	Momentum Equations and Reynolds Stresses for an Incompressible Flow	290		
	10.10	Turbulent Lubrication Theories	291		
	10.11	Derivation of Reynolds Equation for			
		Turbulent Lubrication	292		
	Referenc	ces	298		
	Appendix 10.1				
	Appendi	x 10.2	301		
Chapter 11:	Gas-lu	ibricated Bearings	303		
	11.1	Introduction	303		
	11.2	Governing Equations	305		
	11.3	Limiting Solution	306		
	11.4	Infinitely Long Plane Slider	308		
	11.5	Finite Journal Bearings	310		
	11.6	Externally Pressurized Gas Bearings	315		
	11.7	Journal Bearings	318		
	11.8	Porous Gas Bearings	321		
	11.9	Circular Porous Thrust Bearing	327		
	11.10	Dynamic Characteristics of Gas-lubricated Bearings	333		
	11.11	Whirl Instability of Gas Bearings	343		
	Referen	ces	346		
Chapter 12:	Hydro	348			
	12.1	Introduction	348		
	12.2	Lubrication of Rolling Rigid Cylinders	348		
	12.3	Isoviscous Lubrication of Rigid Spherical Bodies			
		in Rolling	353		
	12.4	Squeeze Film Lubrication in Nonconformal Contacts	358		
	12.5	Effect of Squeeze Motion on the Lubrication of Rigid Solids	362		
	12.6	Hydrodynamics of Rigid Point Contacts in Combined			
		Rolling and Normal Motion	363		
	Problem	ns —	368		
	Referen	ces	369		

,							
	Λ	n	•	ø	n	ts	
*	v		•	Ų,	,,	4.3	

C1 . 10	7731 .		370	
Chapter 13:	Elastohydrodynamic Lubrication			
	13.1	Introduction	370	
	13.2	Line Contact Analysis	371	
	13.3	Point Contact Analyses	381	
	13.4	Different Regimes in EHL Contacts	390	
	13.5	Mixed Lubrication	391	
	Referen	ces	398	
Chapter 14:	Vibration Analysis with Lubricated Ball Bearings			
	14.1	Introduction	401	
	14,2	Rotor Supported on Lubricated Ball Bearings	402	
	14.3	Nonlinear Structural Vibration Analysis in Lubricated		
		Ball Bearings	417	
	Referen	ces	434	
Chapter 15:	Therm	nal Effect in Rolling-Sliding Contacts	437	
	15.1	Thermal Analysis of Rigid Rolling-Sliding Contacts	437	
	15.2	Thermal Analysis of Elastohydrodynamic Lubrication of Line Contacts	449	
	15.3	Thermal Traction and Temperature Rise in the Eastohydrodynamic Line		
		Contacts	460	
	References			
	Append	ix 15.1	468	
	Index		469	