## **Contents**

reface	
Acknowledgments	xii
1. Rotary Drilling for Oil and Natural Gas	
Introduction	
The Process of Rotary Drilling	
Rotary Drilling Rigs	
Rig Selection	
Rotary Drilling Systems	
Mud System Evaluation	
Rotary System	
Well Control System	
Data Acquisition and Monitoring System	
Special Systems for Offshore Drilling	
Supplementary Problems	
Nomenclature	36
2. Drilling Fluids	37
Characteristics of a Drilling Fluid	
Drilling-Fluid Selection	
Classification of Drilling Fluids	44
Water-Based Drilling-Mud Contaminants	47
Drilling-Mud Properties, Field Tests, and Control	49
Alkalinity (M, P <sub>f</sub> , P <sub>m</sub> , M <sub>m</sub> , P <sub>1</sub> , P <sub>2</sub> )	
Mud Rheology	64
Drilling-Mud Additives	
Supplementary Problems	78
Nomenclature	82
3. Fluid Flow and Associated Pressures in the Rotary Rig	
Circulating System	85
Introduction	
Mechanical Energy and Pressure Balance	
Pressure Drop across the Bit Nozzles (Jets)	
Friction Pressure Losses in the Rotary Rig Circulating System	
Friction Pressure Losses in Pipes and Annuli—Laminar Flow	97
Friction Pressure Losses in Pipes and Annuli—Turbulent Flow	116
Equivalent Newtonian Viscosity	
Turbulent Pipe Flow of Non-Newtonian Fluids	
Turbulent Annular Flow of Non-Newtonian Fluids	
Annular Friction Pressure Losses Due to Pipe Movement	

## viii Drilling Engineering

Supplementary Problems	130
Nomenclature	138
References	139
4. Drill Bit Hydraulics	141
Introduction	
Pump Pressure Requirement in Rotary Drilling	
Hydraulic Power Requirement	
Flow Exponent (\alpha)	
Maximum Drill Bit Hydraulic Horsepower Criterion	
Maximum Jet Impact Force Criterion	
Supplementary Problems	
Nomenclature	
References	170
5. Transport of Drilled Cuttings	171
Introduction	
Factors that Affect the Transport of Drilled Cuttings	171
Cuttings Transport in Vertical Well Drilling	
Cuttings Transport in Directional Well Drilling	
Empirical Correlations for Cuttings Transport in High-Angle Wells ( $\theta > 50^{\circ}$ )	
Supplementary Problems	
Nomenclature	189
References	189
3. Prevention and Control Mechanics of Well Blowouts	191
Introduction	191
Kick Causes	191
Kick Detection	195
Kick Prevention	
Fundamentals of Well Control	196
Well Control System	199
Principles of Well Control	206
Commonly Used Well Control Methods	216
Nonconventional Kick Situations	225
Supplementary Problems	230
Nomenclature	234
References	235
7. Directional and Horizontal Well Drilling	237
Directional Well Drilling	
Horizontal Well Drilling	254
Tortuosity	265
Supplementary Problems	
	271
Nomenclature	271

8. Drill Bit Mechanics	277
Introduction	
Bit Selection	
Types of Drill Bits	
Classification of Roller Cone Drill Bits	
Drill Bit Operating Parameters	
Grading of Dull Drill Bits	
Classification of Drag Drill Bits	
Rock Mechanics	
Performance Mechanics of Drag Drill Bits	
Supplementary Problems	
Nomenclature	
References	
9. Drill String Design	319
Definition and Components	
Design Criteria	
Buckling of the Drill String	
Drill String Fatigue	
Dril String Vibration	
BHA Design for Directional Drilling	
Deviation Tools	
Supplementary Problems	
Nomenclature	
References	
10. Drilling Problems and Solutions	355
Introduction	
Pipe Sticking	
Loss of Circulation	
Hole Deviation	
Drill Pipe Failures	
Borehole Instability	
Mud Contamination	
Producing-Formation Damage	
Hole Cleaning	
Hydrogen Sulfide—Bearing Zones and Shallow Gas	
Equipment- and Personnel-Related Problems	
Supplementary Problems	
Nomenclature	
References	
11. Casing and Cementing Design	381
Drilling the Pay Zone: Selecting the Interval and the Initial Design	
Initial Completion Design	
Casing Design	

## x Drilling Engineering

	Cementing	422
	Supplementary Problems	
	Nomenclature	
	References	447
12	2. Well Planning in Drilling Engineering	451
	Introduction	
	Objectives	
	Information Needed for Effective Well Planning	452
	Responsibilities of the Drilling Engineer	
	Considerations in Well Planning	
	The Drilling Program	
	Post-Well Analysis	
	Well Cost Estimation	
	Learning Curve	
	Cost Control in Well Drilling	
	Time Value of Money	
	Price Elasticity	
	Supplementary Problems	
	Nomenclature	
	References	
In	ndex	465