

The background of the cover is a photograph of an oil rig. Two workers in yellow protective suits and hard hats (one white, one blue) are seen from behind, working on the complex metal structure of the rig. The rig features various pipes, beams, and chains, with some parts painted in red and yellow. The sky is a clear, pale blue.

Working Guide to
**Reservoir Rock
Properties and Fluid Flow**

Tarek Ahmed

G | P
P | 

Contents

1

FUNDAMENTALS OF RESERVOIR FLUID BEHAVIOR

Section 1.1 Classification of Reservoirs and Reservoir Fluids	1
Pressure-Temperature Diagram	2
Oil Reservoirs	3
Gas Reservoirs	9
Undefined Petroleum Fractions	25
Section 1.2 Problems	29
Section 1.3 References	30

2

FUNDAMENTALS OF ROCK PROPERTIES

Section 2.1 Porosity	32
Absolute Porosity	32
Effective Porosity	33
Section 2.2 Saturation	36
Average Saturation	38
Section 2.3 Wettability	40
Section 2.4 Surface and Interfacial Tension	40
Section 2.5 Capillary Pressure	43
Capillary Pressure of Reservoir Rocks	46
Capillary Hysteresis	49
Initial Saturation Distribution in a Reservoir	51
Leverett J-Function	61
Converting Laboratory Capillary Pressure Data	64
Section 2.6 Permeability	65
The Klinkenberg Effect	71
Averaging Absolute Permeabilities	76
Absolute Permeability Correlations	84

Section 2.7 Rock Compressibility	87
Section 2.8 Net Pay Thickness	92
Section 2.9 Reservoir Heterogeneity	93
Vertical Heterogeneity	94
Section 2.10 Areal Heterogeneity	104
Section 2.11 Problems	110
Section 2.12 References	115

3

FUNDAMENTALS OF RESERVOIR FLUID FLOW

Section 3.1 Types of Fluids	117
Incompressible Fluids	118
Slightly Compressible Fluids	118
Compressible Fluids	119
Section 3.2 Flow Regimes	120
Steady-State Flow	121
Unsteady-State Flow	121
Pseudosteady-State Flow	121
Section 3.3 Reservoir Geometry	122
Radial Flow	122
Linear Flow	123
Spherical and Hemispherical Flow	123
Section 3.4 Number of Flowing Fluids in the Reservoir	125
Section 3.5 Fluid Flow Equations	125
Darcy's Law	125
Section 3.6 Steady-State Flow	127
Linear Flow of Incompressible Fluids	128
Linear Flow of Slightly Compressible Fluids	132
Linear Flow of Compressible Fluids (Gases)	133
Radial Flow of Incompressible Fluids	138
Radial Flow of Slightly Compressible Fluids	143
Radial Flow of Compressible Gases	144
Horizontal Multiple-Phase Flow	151
Section 3.7 Unsteady-State Flow	153
Basic Transient Flow Equation	155
Radial Flow of Slightly Compressible Fluids	159

Section 3.8 Constant-Terminal-Pressure Solution	162
Section 3.9 Constant-Terminal-Rate Solution	163
The E_i -Function Solution	163
The Dimensionless Pressure Drop (p_D) Solution	170
Radial Flow of Compressible Fluids	179
The $m(p)$ -Solution Method (Exact Solution)	181
The Pressure-Squared Approximation Method (p^2 -Method)	183
The Pressure-Approximation Method	185
Section 3.10 Pseudosteady-State Flow	188
Radial Flow of Slightly Compressible Fluids	193
Radial Flow of Compressible Fluids (Gases)	201
Pressure-Squared Approximation Method	201
Pressure-Approximation Method	202
Skin Factor	202
Turbulent Flow Factor	208
Section 3.11 Principle of Superposition	211
Effects of Multiple Wells	212
Effects of Variable Flow Rates	215
Effects of the Reservoir Boundary	218
Accounting for Pressure-Change Effects	221
Section 3.12 Transient Well Testing	221
Drawdown Test	222
Pressure Buildup Test	233
Section 3.13 Problems	241
Section 3.14 References	245
INDEX	247