

Contents

<i>Preface of Set I</i>	vii
<i>Preface</i>	xiii
<i>About the Editor-in-Chief</i>	xv
<i>List of Contributors</i>	xvii
Chapter 1. Introduction	1
1. Heat Exchangers	1
2. Oil and Gas Transport	2
3. Geothermal Energy Plants	2
4. Solar Energy Power Plants	3
5. Micro Electronic Devices	4
6. Nuclear Reactors	6
7. Climate Control in Space Vehicles	6
Chapter 2. Basic Definitions of Two-Phase Flow Parameters	9
1. Void Fraction	9
2. Density	10
3. Mass Concentration	10
4. Superficial Velocity, Volumetric Flux	10
5. Mass Flux	11
6. Velocity	11
7. Relative or Slip Velocity	11
8. Slip Ratio	11
9. Drift Velocity	12
10. Drift Flux	12
11. Diffusion Velocity	12
12. Quality	13

13. Some Relations	13
14. Zuber–Findlay Distribution Parameter	14
Reference	14
Chapter 3. Simplified Methods	15
1. Steady Homogeneous Model	15
2. Lockhart–Martinelli Model	18
References	21
Chapter 4. Hydrodynamic Models Based on Flow Patterns	23
1. Steady Stratified Flow	25
2. Steady Annular Flow	30
2.1. Interfacial shear	32
2.2. Two-dimensional solution for the film	34
3. Dispersed Bubble Flow	35
3.1. Bubble rise velocity	36
4. Slug Flow	38
4.1. Mass balances	40
4.2. Average void fraction	42
4.3. Hydrodynamics of the liquid film	42
4.4. Pressure drop	47
4.5. Auxiliary relations	50
4.5.1 The translational velocity	50
4.5.2. Bubbles velocities in the liquid slug	64
4.5.3. Void fraction in the liquid slug	65
4.5.4. Slug length	70
4.5.5. Taylor bubble bottom oscillation	76
5. Severe Slugging	82
5.1. The severe slugging cycle	83
5.2. Boe’s criterion for severe slugging	86
5.3. The stability criterion	88
5.4. Quasi-equilibrium severe slugging	90
5.5. Summary	92
References	93
Chapter 5. Flow Pattern Transition	101
1. Introduction	101
2. The Unified Model	105
2.1. Transition from dispersed bubble flow	107
2.2. The stratified–non-stratified transition	110

2.3.	Transition from annular to intermittent flow	116
2.3.1.	The stability criterion [mechanism (a)]	120
2.3.2.	The spontaneous blockage criterion [mechanism (b)]	121
2.3.3.	The combined criterion	121
2.3.4.	Effect of pipe inclination	122
2.4.	Sub regions within intermittent flow	124
2.5.	Sub regions in stratified flow	125
2.6.	Summary	126
	References	127

Chapter 6. The Two Fluid Model 131

1.	The Two Fluid Model — Formulation	131
1.1.	Reynolds transport theorem	132
1.2.	Continuity equations	134
1.3.	Momentum equations	135
1.4.	Energy equations	137
1.5.	Stratified flow, constant properties	139
2.	Hyperbolic System and Well Posedness	141
2.1.	Example: Open channel flow	143
2.2.	Characteristics and well posedness of stratified flow	145
2.3.	Stratified flow with surface tension	146
3.	Stability of Separated Flow	147
3.1.	Interfacial linear stability	149
3.2.	IKH instability	152
3.3.	VKH instability	155
3.4.	Application to flow pattern transition	157
3.5.	Nonlinear interfacial stability	160
3.6.	Comparison with experimental results	167
3.7.	Structural stability	169
3.7.1.	Annular flow	169
3.7.2.	Stratified flow	175
3.8.	Summary	179
4.	Relation Between Stability and Well Posedness	180
4.1.	Well posedness analysis	180
4.2.	Stability analysis	181
4.3.	Comparison between stability and well posedness	181
	References	183

Chapter 7. The Drift Flux Model 185

1.	Continuity of the Mixture	185
2.	Mass Conservation of One Species	186

3. Mixture Momentum Equation	186
4. Mixture Energy Equation	187
5. Characteristics Analysis — the Homogeneous Case	188
6. Speed of Sound for a Homogeneous Equilibrium Mixture	192
7. Empirical Relations for the Drift Velocity	193
References	194
Chapter 8. Flow in Parallel Pipes	195
1. Evaporating Flows	196
1.1. (a) The three-zone model	198
1.2. (b and c) Pipe discretization models	207
1.3. Summary	212
2. Adiabatic Flow	213
2.1. Analysis	214
2.2. Experimental results	219
2.3. Summary	220
References	221
Chapter 9. Flooding and Flow Reversal	225
1. Introduction	225
2. Prediction Methods	229
3. Vertical Flow	229
4. Inclined Flow	237
5. Summary	243
References	244
Index	249