

Contents

Preface — vii

Introduction — xii

1 The principles and modes of distillation — 1

1.1 Simple distillation — 1

1.2 Flash distillation — 2

1.3 Multistage distillation — 2

2 Assumptions and problem reduction — 5

3 The basic equations of distillation — 6

3.1 Mass balance — 6

3.2 Vapour-liquid-equilibria — 7

3.2.1 Ideal mixtures — 7

3.2.2 Real mixtures — 7

3.3 Mass transfer correlations — 8

3.4 Distillation in a packed mass transfer section — 9

3.4.1 Distillation at total reflux ($L/V = 1$) — 9

3.4.2 Effect of the ratio of the mass transfer coefficients — 10

3.4.2.1 Mass transfer resistance exclusively in the vapour phase ($k = 0$) — 10

3.4.2.2 Mass transfer resistance exclusively in the liquid phase ($k = \infty$) — 10

3.5 Distillation in a mass transfer section with theoretical stages — 11

3.6 Distillation at partial reflux ($L \neq V$) — 12

3.7 Simple distillation — 15

3.8 Reversible distillation — 16

4 Distillation of ideal mixtures — 17

4.1 Binary mixtures — 17

4.1.1 Distillation at total reflux — 17

4.1.1.1 Mass transfer section with a packing — 17

4.1.1.2 Mass transfer section with theoretical stages — 18

4.1.2 Distillation at partial reflux — 18

4.1.2.1 Mass transfer section with a packing or theoretical stages — 18

4.1.3 Distillation column with a rectifying and a stripping section — 20

4.1.3.1 McCabe-Thiele-diagram — 20

4.1.3.2 Limiting flow ratios (Minimum reflux condition) — 21

4.1.3.3 Optimal feed location — 25

4.1.3.4 Optimal flow ratios — 25

4.2	Ternary mixtures — 27
4.2.1	Distillation at total reflux and simple distillation — 27
4.2.1.1	Vector field of the differential equation — 27
4.2.1.2	Field of distillation lines — 28
4.2.1.3	Effect of the mass transfer resistance — 30
4.2.2	Distillation at partial reflux — 32
4.2.2.1	Vector fields at partial reflux — 34
4.2.2.2	Distillation spaces and separation lines — 34
4.2.2.3	Calculation of the distillation lines — 38
4.2.3	Reversible distillation — 41
4.2.4	Product domains — 42
4.2.4.1	Product domains in reversible distillation — 42
4.2.4.2	Product domains of the mass transfer and theoretical stage concept based distillation (adiabatic distillation) — 45
4.2.5	Distillation column — 46
4.2.5.1	Distillation at the limiting flow ratios — 46
4.2.5.2	Distillation at non-limiting flow ratios — 54
4.2.5.3	Optimal feed location — 55
4.2.6	The fundamental equation of distillation — 58
4.2.6.1	The line function of distillation — 59
4.2.6.2	The potential function of distillation — 59
4.3	Quaternary mixtures — 61
4.3.1	Distillation lines — 61
4.3.2	Product domains — 63
4.3.2.1	Reversible distillation — 63
4.3.2.2	Adiabatic distillation — 63
4.4	Multicomponent mixtures — 66
4.4.1	Distillation at total reflux — 67
4.4.2	Distillation at partial reflux — 68
4.4.2.1	Product compositions — 69
4.4.2.2	Sequencing of distillation columns — 70
4.5	The conceptual design of the distillation of multicomponent mixtures — 74
4.5.1	Initial conditions — 74
4.5.2	Determination of the product flow rates — 75
4.5.3	Determination of the distillation lines — 75
4.5.3.1	Numerical solution of the differential equations — 75
4.5.3.2	Distillation spaces and distillation lines based on the algebraic solution of the differential equations — 75

5	Distillation of real mixtures — 76
5.1	Zeotropic mixtures — 77
5.1.1	Binary mixtures — 77
5.1.1.1	Enthalpy-concentration-diagram — 77
5.1.2	Ternary mixtures — 78
5.1.2.1	Distillation at total reflux — 79
5.1.2.2	Distillation at partial reflux — 79
5.1.2.3	Product domains and minimum flow ratio — 80
5.1.3	Multicomponent mixtures — 82
5.2	Azeotropic mixtures — 82
5.2.1	Binary mixtures — 82
5.2.2	Ternary mixtures — 84
5.2.2.1	Distillation at total reflux — 85
5.2.2.2	Distillation at partial reflux — 91
5.2.3	Multicomponent mixtures — 94
6	Computer programs — 95
7	Nomenclature — 98
8	Glossary — 101
A	Appendices — 102
A.1	Coordinate transformation — 102
A.2	Distillation of an ideal five-component mixture — 103
A.2.1	Conceptual design — 103
A.2.2	Geometry of the distillation column [17, 57] — 105
Index	— 106