



Technology Training that Works

Practical Fundamentals of Chemical Engineering

Contents

1	Chemical engineering- an overview	1
1.1	Basics of chemical engineering	1
1.2	Unit operations	2
1.3	Thermodynamics	8
1.4	Chemical Kinetics	9
1.5	Chemical engineer – scope & responsibilities	9
1.6	“Ten greatest achievements” of chemical engineering	15
1.7	Chemical engineering “Today & Tomorrow”	17
2	Stoichiometry	19
2.1	Introduction	19
2.2	Understanding chemical formulas and equations	19
2.3	Balancing chemical equations	25
2.4	Chemical periodicity	27
2.5	Molecular weight	28
2.6	The mole and molar mass	29
2.7	Percent composition	29
2.8	Introduction to solutions	32
2.9	Units and dimensions	33
2.10	Process variables	36



Technology Training that Works

3	Chemical kinetics	41
3.1	Chemical reactions – Basic concepts	41
3.2	Classification of chemical reactions	42
3.3	Chemical reaction profile	43
3.4	Classification of reactors	44
3.5	Catalysts	49
3.6	Promoters	53
3.7	Efficiency criteria of a chemical process	55
4	Fluid mechanics	57
4.1	Introduction	57
4.2	Volumetric properties of liquids	57
4.3	Liquid-column manometers	58
4.4	Mechanical pressure gauges	61
4.5	Measurement of fluid flow	65
4.6	Valves	82
4.7	Fluid moving machinery	90
4.8	Centrifugal pumps	91
4.9	Positive-displacement pumps	92
4.10	Agitation equipments	96
5	Heat transfer and its applications	101
5.1	Heat transfer mechanism	101
5.2	Heat exchangers	101
5.3	Boilers	111
5.4	Evaporators	115



Technology Training that Works

6	Mass transfer and its applications	125
6.1	Mass transfer phenomena	125
6.2	Distillation	125
6.3	Types of distillation columns	127
6.4	Column internals	128
6.5	The types of distillation	137
6.6	Sublimation	143
6.7	Leaching	143
6.8	Centrifugal extractors	148
6.9	Gas absorption	149
6.10	Cooling towers	152
6.11	Desiccant dehumidifiers	157
6.12	Adsorptions systems	159
6.13	Drying	163
6.14	Drying equipment	164
7	Thermodynamics	183
7.1	Applications of thermodynamics principles	183
7.2	Compressor	187
7.3	Ejector-system	194
7.4	Heat conversion & power cycles	195
7.5	Refrigeration and liquefaction	211
8	Process design	217
8.1	Introduction	217
8.2	Process design considerations	218
8.3	Equipment design factors	218
8.4	A look at common industrial chemicals	219



Technology Training that Works

8.5	Materials of construction	221
8.6	Types of corrosion	222
8.7	Linings for chemical plants and equipment	223
8.8	Rules of thumb	224
9	Process control	231
9.1	Overview	231
9.2	Control system	231
9.3	Practical control examples	234
9.4	Control actions	240
9.5	Examples of control	241
9.6	Control loop diagrams	248
9.7	Modes of automatic control	249
10	Chemical process safety	259
10.1	Safety responsibilities	259
10.2	Standard safety rules and regulations	261
10.3	Chemical hazards and chemical safety data sheets	262
10.4	General safety practices	266
10.5	Good housekeeping plan	276
10.6	Personal protective equipments	276
11	Classification of process diagrams/data sheets and their application	277
11.1	Introduction	277
11.2	Types of process drawings	277
11.3	Block Flow Diagram (BFD)	277
11.4	Process Flow Diagram (PFD)	278
11.5	Piping and Instrument Diagram (P&ID)	279



Technology Training that Works

11.6	Utility Flow Diagram (UFD)	280
11.7	Data sheets	280
12	Unit operations of particulate solids	283
12.1	Storage of solids	282
12.2	Feeders	286
12.3	Crushers and mills	288
12.4	Cutting machines	295
12.5	Crystallization	296
12.6	Mixers	298
12.7	Mechanical separation	301
12.8	Powder compacting equipments	306
12.9	Filtration	310
12.10	Cryogenic grinding	314
12.11	Blending	315
13	Process economics	317
13.1	Capital investment	317
13.2	Total product costs	319
13.3	Economic analysis	320
13.4	Life cycle analysis	321
13.5	Real-Time Optimization (RTO) of chemical processes	322
Appendix A Periodic Table		325
Appendix B Fundamental physical constants		327
Appendix C Process equipment symbols		331



Technology Training that Works

Appendix D Typical instrumentation representation	349
Appendix E Typical P&ID	375
Appendix F Typical process data sheet	377
Appendix G Some websites for safety information	379
Appendix H Practical exercises	383