

A REAL-TIME APPROACH TO PROCESS CONTROL

SECOND EDITION

WILLIAM Y. SVRCEK

DONALD P. MAHONEY

BRENT R. YOUNG

 WILEY

Contents

Preface	xi
Acknowledgements	xiii
Endorsement	xv
About the authors	xvii
1 A brief history of control and simulation	1
1.1 Control	1
1.2 Simulation	3
1.3 References	10
2 Process control hardware fundamentals	13
2.1 Control system components	13
2.2 Primary elements	14
2.3 Final control elements	30
2.4 References	50
3 Fundamentals of single input–single output systems	51
3.1 Open-loop control	51
3.2 Disturbances	52
3.3 Feedback control overview	53
3.4 Feedback control: a closer look	56
3.5 Process attributes: capacitance and dead time	61
3.6 Process dynamic response	71
3.7 Process modelling and simulation	73
3.8 References	92
4 Basic control modes	93
4.1 On–off control	93
4.2 Proportional (P-only) control	95
4.3 Integral (I-only) control	101
4.4 Proportional plus integral (PI) control	104

4.5 Derivative action	105
4.6 Proportional plus derivative (PD) controller	107
4.7 Proportional integral derivative (PID) control	110
4.8 Choosing the correct controller	111
4.9 Controller hardware	113
4.10 References	115
5 Tuning feedback controllers	117
5.1 Quality of control and optimisation	117
5.2 Tuning methods	122
5.3 References	130
6 Advanced topics in classical automatic control	131
6.1 Cascade control	131
6.2 Feedforward control	135
6.3 Ratio control	138
6.4 Override control (auto selectors)	140
6.5 References	146
7 Common control loops	147
7.1 Flow loops	147
7.2 Liquid pressure loops	149
7.3 Liquid level control	151
7.4 Gas pressure loops	162
7.5 Temperature control loops	163
7.6 Pump control	170
7.7 Compressor control	170
7.8 Boiler control	177
7.9 References	180
8 Distillation column control	183
8.1 Basic terms	183
8.2 Steady-state and dynamic degrees of freedom	184
8.3 Control system objectives and design considerations	186
8.4 Methodology for selection of a controller structure	188
8.5 Level, pressure, temperature and composition control	190
8.6 Optimizing control	198
8.7 Distillation control scheme design using steady-state models	202
8.8 Distillation control scheme design using dynamic models	213
8.9 References	214
9 Using steady-state methods in a multi-loop control scheme	215
9.1 Variable pairing	215
9.2 The relative gain array	216
9.3 Niederlinski index	221
9.4 Decoupling control loops	221
9.5 Tuning the controllers for multi-loop systems	223

9.6 Practical examples	223
9.7 Summary	234
9.8 References	234
10 Plant-wide control	237
10.1 Short-term versus long-term control focus	237
10.2 Cascaded units	239
10.3 Recycle streams	241
10.4 General considerations for plant-wide control	246
10.5 References	247
Appendices	
1 P&ID symbols	249
2 Glossary of terms	253
A2.1 Reference	259
Workshops	
1 Learning through doing	265
2 Feedback control loop concepts	269
3 Process capacity and dead time	275
4 Feedback control	283
5 Controller tuning for capacity and dead time processes	291
6 Topics in advanced control	297
7 Distillation control	307
8 Plant operability and controllability	315
Index	323