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Guide to Selected Process Examples

APPENDIX G

Because of the strong interplay between process dynamics and control performance, examples should begin with process equipment and operating conditions. To this end, several process examples are introduced in the beginning chapters and used in many subsequent worked examples and questions. This approach has three advantages. First, the performance of different control approaches (e.g., tuning or control algorithm) can be evaluated on the same processes, allowing clear comparisons of competing methods. Second, the reader can concentrate on the learning objective applied to a familiar process. A final advantage is the reduction in the size of the book, since each example takes considerable space to introduce completely.

Since the reader may want to review the control approaches applied to a process, this guide is provided. Major worked examples and questions involving the most important processes are summarized in the tables. The symbols used in the tables are Ex for a worked example, Q for a question at the end of a chapter, S for a chapter section, F for a figure, and T for a table; as elsewhere, the number (or letter) before the period indicates the chapter (or appendix).

G.1 ■ HEAT EXCHANGER

This is a simple model of a heat exchanger. Since the process fluid side is well mixed and the utility side is at quasi-steady state, the basic model is first-order, which allows some analytical solutions to be determined. See Table G.1.

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TABLE G.3

Nonisothermal CSTR

	Key issue addressed		Key issue addressed
S 3.6	Dynamic behavior	Q 20.11	Integral controllability, loop pairing, and tuning for various sets ofdesign parameters
S 7.3	Selecting variables		
Q 7.1	Causal relationship		
Q 7.9	Evaluate proposed single-loop feedback control structures	F 22.5 F 22.6	Variable-structure control, signal select
Q 7.11*b*	Operating window	Ex 24.4	Dynamic transient exceeding steady-state operating window
Q 8.17	General behavior under P-only and PD control	S C.1	Derivation of energy balance
Q 10.11	Effect of process and control structure on possible dynamic responses	S C.2	Modelling linearization
		S C.3	Transfer function
		S C.4	Possibility of multiple steady states and their stability
Q 12.6	Failure modes		
Ex 13.12	Selecting manipulated variable	S C.5	Possibility of limit cycles
Q 13.14	Control performance	Q C.1	Modified process model
Ex 14.7	Cascade design	Q C.2	Transfer function
Q 14.11	Cascade design	Q C.3	Frequency response
Q 20.2	The effect of ΔH_{rxn} on multiloop stability and dynamic response	Q C.4	Empirical identification

TABLE G.4

Two-product distillation column

	Key issue addressed		Key issue addressed
Q 2.8*	Effect of distribution on profit	Ex 21.3	Effect of disturbance type on multiloop control performance
Q 2.9*	Effect of distribution on profit		
S 5.6	Model development	Ex 21.6	Relative gain and loop pairings
Ex 5.4	Simulated dynamic response	Ex 21.9	Match tuning with performance goals
Q 6.10	Process reaction curve		
Q 14.6*	Cascade control	Ex 21.10	Decoupling, perfect and with model errors
Ex 15.7*	Feedforward control		
S 17.5*	Inferential tray temperature	Q 21.1*	Tuning, loop pairing, performance and decoupling
Ex 20.2	Linearized model		
Ex 20.4	Operating window	Q 21.8*	Tuning, loop pairing, performance and decoupling
Ex 20.5	Evaluation of controllability		
Ex 20.7	Effect of interaction on the changes in manipulated variable	Q 21.11*	Control loop pairing
		Ex 23.1	Complexity of analytical inverse
Q 20.9*	Controllability, interaction, tuning	Ex 23.6	DMC control
Q 20.15*	Controllability, interaction, tuning	Ex 23.8	QDMC control
Ex 21.2	Effect of control structure on multiloop control performance	Appendix J	Control Design

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G.[illegible] HEAT EXCHANGE AND FLASH DRUM

A flash drum at controlled pressure and temperature is a simple method for effecting a physical separation of components with different vapor pressures. This process provides the opportunity to evaluate inferential control and pair loops for dynamic performance. See Table G.6.

TABLE G.5

Two isothermal CSTRs

	Key issue addressed		Key issue addressed
Ex 3.3	Derive process model and evaluate a step response	Q 9.10	Effect of changing temperature on tuning
Q 3.14	Pulse response	Ex 10.4	Roots of closed-loop characteristic equation (modified process)
Ex 4.6	Solve step response using Laplace transforms (slightly modified model)	Ex 10.8	Repeat Ex 10.4 with additional dead time
Ex 4.8	Stability	Q 10.11	Effect of process and control structure on possible dynamic responses
Ex 4.9	Derive the transfer function	Ex 13.8	Effect of inverse response on control performance
Ex 4.11	Damping	Q 13.18	Effect of an alternative manipulated variable on control performance
Ex 4.12	Block diagram	Q 15.11	Effect of dynamics on feedforward-feedback control
Ex 4.16	Frequency response	Q 21.10	Multiloop control
Q 4.1	Emergency response	Ex I.2	Model with solvent flow adjusted
Q 4.7	Modified inputs	Q I.3	Model with F_A adjusted
Q 4.16	Derive model and dynamic response for a different input variable	Q I.4	Control design
Q 5.4	Four series reactors		
Q 7.3	Causal relationship		
Q 7.11c	Operating window		
Q 8.15	Loop behavior		

TABLE G.6

Heat exchange and flash drum

	Key issue addressed		Key issue addressed
Q 1.6	Control system components	Ex 24.5	Degrees of freedom
S 2.2	Control objectives	Ex 24.6	Controllability
S 17.2	Inferential variable evaluation	Ex 24.7	Operating window
Q 17.2	Model analysis	Ex 24.8	Loop pairing
Q 17.12	Controllability	Ex 24.9	Algorithm selection and tuning
Q 21.5	Loop pairing	Ex 24.10	Control for safety
T 24.1	Control design form (CDF)	Ex 24.11	Process monitoring
Ex 24.1	Sensors	Ex 24.12	Dynamic performance
Ex 24.2	Control objectives	Q 24.22	Partial control
Ex 24.3	Final elements		