

Process Control, 3P4

Assignment 1

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Assignment objectives: understanding about feedback systems; dynamic models

Question 1 [4]

Select a system from everyday life that employs feedback in its operation. Describe the system and how feedback is used. A sketch of the system is required.

Question 2 [8]

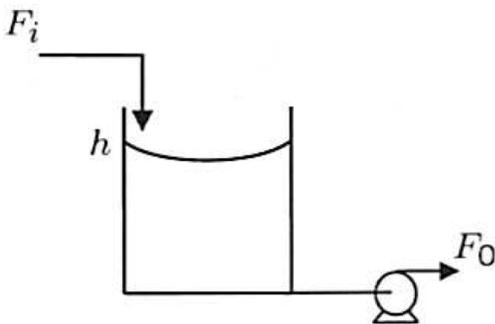
Select a process that you have studied in a previous course in chemical engineering (e.g. heat exchangers, separation process, reactors) and describe the objectives that should be associated with each of the seven categories of control objectives described in Chapter 2 of the textbook. A sketch of the process is required.

Question 3 [4]

What is the economic cost of an error of 0.5% in the flow rate for a pipeline that carries 100,000 barrels/day of crude oil? (assume the error is not in your favour, i.e. it really is a cost, and not a profit)

Question 4 [20]

Consider the following tank system:



1. Write out the mass balance for the tank in the form:

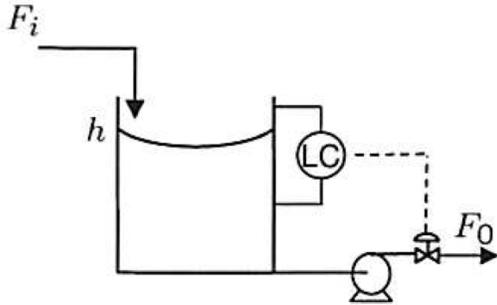
$$\text{rate of accumulation of mass} = \text{rate of mass flow in} - \text{rate of mass flow out}$$

so that you obtain a differential equation relating height h , flows F_i and F_o , and the cross-sectional area, A . The flows are considered to be volumetric flows.

2. Let the flows be $F_i = 10 \text{ m}^3 \cdot \text{min}^{-1}$ and $F_o = 11.5 \text{ m}^3 \cdot \text{min}^{-1}$, the area is $A = 2 \text{ m}^2$, and the current height in the tank is 3 m.

Solve the differential equation by hand to determine an analytical expression of the tank height as a function of time, i.e. $h(t) = \dots$

3. Sketch your function over time, for a duration of 3 minutes.
4. What is the tank level at $t = 2$ minutes?
5. Create a simulation of the system in MATLAB, and integrate the ODE using the MATLAB solver `ode45` (. . .), which you learned about in Chemical Engineering 3E04. Print and attach your plot, showing that your simulation matches the solution to part 3 and 4 above.
6. Now we add a simple controller to the system, a *proportional controller*.



A proportional controller modifies the valve position, *in proportion to* the error, or deviation from set point. The set point is $h_s = 2.0$ m. When there is no deviation, the controller makes no change to the valve. If there is a high deviation from set point, it makes a greater change. The control algorithm can be represented as:

$$F_0(t) = F_{0,s} + K_c(h - h_s)$$

where the error term is $h - h_s$, and the controller tuning constant is $K_c = 8 \text{ m}^2 \cdot \text{min}^{-1}$. The term $F_{0,s} = 10 \text{ m}^3 \cdot \text{min}^{-1}$ represents the amount of flow leaving the tank when there is no error (i.e. when the height is equal to the set point).

Add this equation to your simulation from part 5 (either add it as a new equation - *preferred* - or substitute it into the previous equation).

Now re-simulate the height in the tank over time for a period of 3 minutes. What do you notice about your simulation, compared to part 5?

Print out and attach your simulation.

END