PROCESS DYNAMICS AND CONTROL

Ali M. Sahlodin
Department of Chemical Engineering
AmirKabir University of Technology
Fall 1397 S.H

Amirkabir University of Technology
(Tehran Polytechnic)

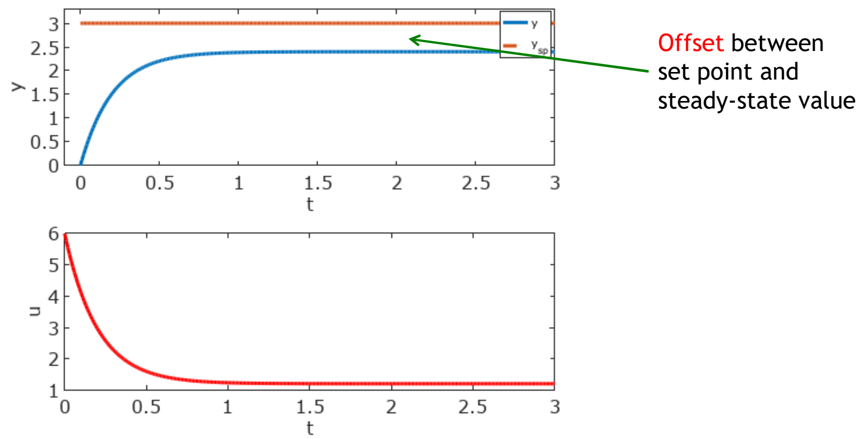
RECAP

- Elements of feedback control
- On/off controller
- Proportional controller

2

PROPORTIONAL CONTROL: STEP CHANGE TO SET POINT

- Does CV reach the set point eventually?



PROPORTIONAL CONTROL: REDUCE OFFSET

$$offset = M(1 - K_1)$$

$$K_1 = \frac{K_C K_P}{1 + K_C K_P} \quad \Rightarrow \quad \text{Increase } K_c$$

- On/off controller is a special case of proportional controller with very large gain
- Disadvantages of larger proportional gains
  - Aggressive control actions
- Can we eliminate offset using a Proportional control?
  - Instability may occur

PROPORTIONAL CONTROL FOR INTEGRATING PROCESSES

- Process model

$$G_p(s) = \frac{K_P}{s} \quad \Rightarrow \quad \frac{y(s)}{y_{sp}(s)} = \frac{K_c \frac{K_p}{s}}{1 + K_c \frac{K_p}{s}}$$

Step change to set point

$$y_{sp}(s) = \frac{M}{s} \quad \Rightarrow \quad y(s) = \frac{M}{s} \frac{K_c K_p}{(s + K_c K_p)}$$

Final-value theorem

$$y(\infty) = \lim_{s \to 0} s \left(\frac{M}{s} \frac{K_c K_p}{(s + K_c K_p)} \right) = M$$

⇒ No offset!

➢ Recall the tank example with a pump in the outlet.

5

BASIC CONTROL MODES: INTEGRAL CONTROL

- Use integral of error

$$p(t) = \bar{p} + \frac{1}{\tau_I} \int_0^t e(t^*) dt^*$$

τ_I : reset time or integral time

- Benefit: elimination of offset
- How is this done?
  - Redo the first-order plant

- Disadvantage of Integral mode
  - Sluggish action (why?)

6

PROPORTIONAL-INTEGRAL (PI) CONTROL

- Combine proportional and integral controllers

$$p(t) = \bar{p} + K_c \left(e(t) + \frac{1}{\tau_I} \int_0^t e(t^*)\, dt^* \right)$$

- Transfer function

$$\frac{P'(s)}{E(s)} = K_c \left(1 + \frac{1}{\tau_I s} \right) = K_c \left(\frac{\tau_I s + 1}{\tau_I s} \right)$$

7

PI CONTROL: ERROR RESPONSE

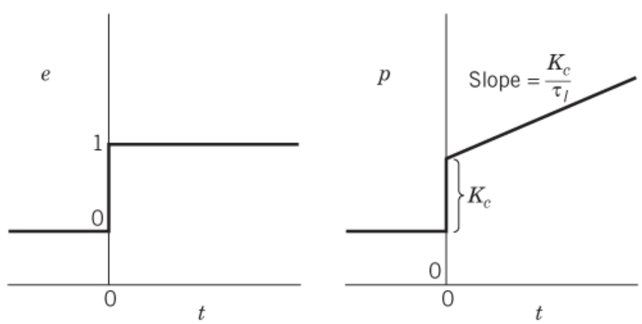


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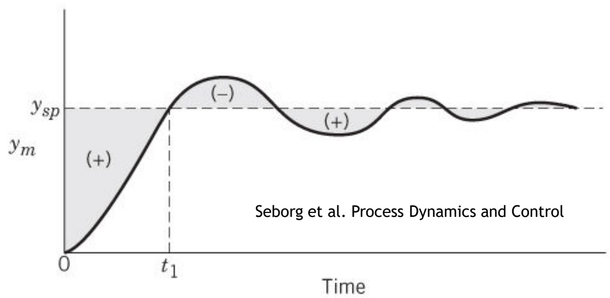
Figure 8.6 Response of proportional-integral controller to unit step change in $e(t)$.

- What if controller output or valve gets saturated?

8

PI CONTROL: CLOSED-LOOP RESPONSE



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9