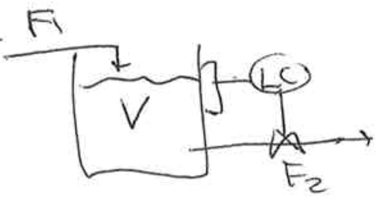
21 SEP. 2007

Should a level controller have integral action?

Probably <u>not</u>, but operators tend to like it.

Example

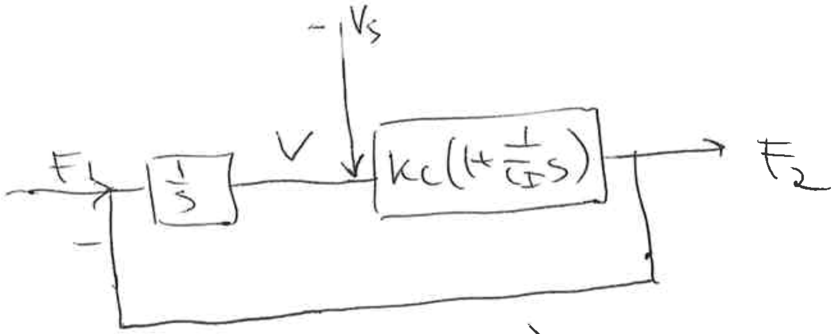


Process

$$\frac{dV}{dt} = F_1 - F_2$$

Controller (c)

$$F_2 = c(V) = K_c\left(V + \int_{-\infty}^{t} \frac{V(t)}{\tau_I}\,dt\right)$$



Note:

$$\frac{F_2}{F_1} = \frac{V}{V_s} \; !!!$$

$$\left(= \frac{L}{1+L}\right)$$

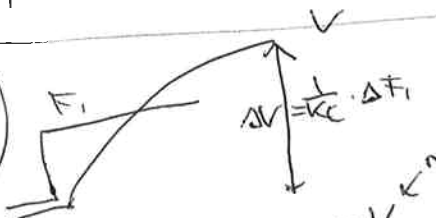
P-control $(\tau_I = \infty)$ $(F_2 = K_c V)$

① $$\frac{F_2}{F_1} = \frac{\frac{K_c}{s}}{1+\frac{K_c}{s}} = \frac{1}{\frac{s}{K_c}+1} = \frac{1}{\tau_c s + 1}$$ (where $K_c = \frac{1}{\tau_c}$)

GOOD!

$$\frac{V}{F_1} = \frac{1/K_c}{\tau_c s+1} \qquad \frac{V}{V_s} = \frac{1}{\tau_c s + 1}$$

Note: Steady-state offset in V to change in F_1 (P-control)



Assume $\Delta V_{max} \approx V_0$ ← nominal volume

$\Delta F_1 \approx F_0$ ← nominal flow

Then: $\Delta V < \Delta V_{max}$

so $\frac{F_0}{K_c} < V_0 \Rightarrow \frac{1}{K_c} < \frac{V_0}{F_0} = \tau_0$

$\boxed{\tau_c < \text{residence time}}$

Must choose

$K_c > 1/\tau_0$ ← residence time!

$(\Leftrightarrow \tau_c < \tau_0)$

PI-control

$$\frac{F_2}{F_1} = \frac{\frac{1}{s}K_c\left(1+\frac{1}{\tau_I s}\right)}{1+\frac{1}{s}K_c\left(1+\frac{1}{\tau_I s}\right)} = \frac{\tau_I s+1}{\frac{s^2}{K_c}\tau_I + \tau_I s + 1}$$

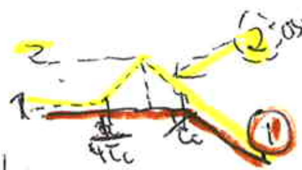
← (same as for P-control as $s \to 0$ $(=1)$ and $s \to \infty$ $\left(= \frac{1}{s/K_c}\right)$ but has a peak at intermediate ω.)

$$\frac{V}{V_s} = \frac{K_c(\tau_I s+1)}{\tau_I s^2 + K_c \tau_I s + 1}$$

more complicated!

1) $\tau_I = 4\tau_c = 4/K_c$:

② $$\frac{F_2}{F_1} = \frac{4\tau_c s+1}{(2\tau_c s+1)^2}$$



Have to "pay" something for the integral action (peak = 2 (asymptote))

2) but smaller peak if τ_I is larger