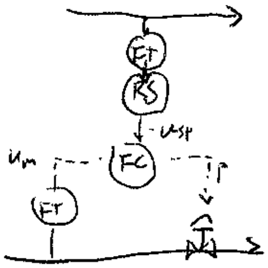
Pset 11

Problem 1 Method II ratio control as discussed in class



$$K_R = \frac{(u_m - u_{m_0})}{(d_m - d_{m_0})}$$

$$u_m = u_{m_0} + K_R(d_m - d_{m_0})$$ ← From 15.1

$$K_R = \frac{u_m - u_{m0}}{d_m - d_{m_0}} = \frac{k_2 u^2}{k_1 d^2} = \frac{k_2}{k_1}\left(\frac{u}{d}\right)^2$$

Transmitter gains

~~$K_{??} / (20-4)\,mA / S_d$~~

$$k_1 = \frac{(15-3)\ psi}{S_d^2} \qquad k_2 = \frac{(15-3)\ psi}{S_u^2}$$

⇐ Hint

Comment on pg. 265, section 15.2

"If orifice plates are used w/ d/P transmitters, then the transmitter output is proportional to the flow rate squared"

$$K_R = \frac{S_d^2}{S_u^2}\left(\frac{u}{d}\right)^2$$

From equation 15.3 this is R_d

they are the desired settings at steady state

$$u/d = R_d$$

Pset 11 problem 2

(a) steady state $s = 0$

$$G_p = 1, \quad G_d = 2, \quad G_v = G_m = G_t = 1$$

from the G_f transfer function we derived in class $G_f = -\frac{G_d}{G_t G_v G_p} = \frac{-2}{(1)(1)(1)} = -2$

(b) again w/ this equation for the feed forward controller

$$G_f = -\frac{G_d}{G_v G_t G_p} = \frac{\frac{-2}{(s+1)(5s+1)}}{(1)(1)\left(\frac{1}{s+1}\right)} = \frac{-2}{5s+1}$$

(c) feedback w/ IMC ... let's do a PID

$$G_p = \frac{1}{s+1} \qquad G_v G_p G_m = \frac{1}{s+1}$$

$K_p = 1$, $\tau_p = 1$, $\theta_p = 0$

$$G_c = K_c\left(1 + \frac{1}{\tau_I s} + \tau_D s\right)$$

$$K_c = \frac{1}{1}\left(\frac{1+0}{0+3}\right) = \frac{1}{3}$$

$$\tau_I = \tau_p + 0.5\theta_p = 1$$

$$\tau_D = \frac{\tau_p \theta_p}{2\tau_p + \theta_p} = \frac{0}{2+0} = 0$$

$$G_c = \left(\frac{1}{3}\right)\left(1 + \frac{1}{s}\right)$$

$$G_c = \frac{\frac{1}{3}(s+1)}{s}$$

(d) FFC only simulate w/ "impulse" for S.S. and dynamic

(e) FB + FFC for S.S. and dynamic

See "PSET 11.m" code for solutions

Note $$\frac{Y(s)}{D(s)} = \frac{G_d + G_t G_f G_v G_p}{1 + G_c G_v G_p G_m}$$

Group Problem 1

(a) $G_p = K_p$, $G_d = K_L$ $\qquad G_v = G_m = G_t = 1$

$K_p \uparrow 2$, $\quad K_L \uparrow -0.5$

First TF $\left(\frac{Y'(s)}{D'(s)}\right)$ is for control variable

Second TF $\left(\frac{Y'(s)}{F'(s)}\right)$ is for disturbance variable

$$G_f = \frac{-G_d}{G_v G_t G_p} = \frac{-0.5}{(1)(1)(2)} = -0.25$$

(b)

$$G_f = \frac{-G_d}{G_v G_t G_p} = \frac{\dfrac{-0.5e^{-30s}}{60s+1}}{(1)(1)\left(\dfrac{2e^{-20s}}{95s+1}\right)} = -0.25\left(\frac{(95s+1)}{(60s+1)}\right)e^{-10s}$$

(c) let's use PI w/ IMC

$$K_c = \frac{1}{K_p}\left(\frac{\tau_p}{\tau_c + \theta}\right) = \frac{1}{2}\left(\frac{95}{30+20}\right) = 0.95$$

$$\tau_I = \tau_p = 95 \qquad G_c = K_c\left(1 + \frac{1}{\tau_I s}\right)$$

(d)
(e) (See Matlab code 'Pset11.m')

Huge improvement w/ dynamic control!
(see plot)

(f) Feedback control + Feedforward control ~~provides~~ w/ dynamic controllers provides the best control (faster, and will account for other disturbances)