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14/ENG01/019
CHEMICAL ENGINEERING

ASSIGNMENT 3

1. $$\frac{dv}{dt} = F_i - F$$

Since $F = B\sqrt{h}$

$$\frac{d(Ah)}{dt} = F_i - B\sqrt{h}$$

$$A\frac{dh}{dt} = F_i - B\sqrt{h} \quad \text{—— (1)}$$

Linearizing $B\sqrt{h}$, we have

$$F(x) = F(x_s) + \left.\frac{df}{dx}\right|_{x=x_s}(x - x_s)$$

$$B\sqrt{h} = B\sqrt{h_s} + \frac{1}{2\sqrt{h_s}}B(h-h_s)$$

$$A\frac{dh}{dt} = F_i - B\sqrt{h_s} + \frac{1}{2\sqrt{h_s}}B(h-h_s)$$

$$A\frac{dh}{dt} = F_i - B\sqrt{h_s} + \frac{B}{2\sqrt{h_s}}B(h-h_s) \quad \text{—— (2)}$$

At steady ~~state~~, equ (1) ~~will~~ becomes

$$A\frac{dh_s}{dt} = F_{is} - B\sqrt{h_s} \quad \text{—— (3)}$$

Subtracting (2) ~~from~~ equ & (3), we have

$$A\frac{dh}{dt} - A\frac{dh_s}{dt} + \left(B\sqrt{h_s} + \frac{B}{2\sqrt{h_s}}(h-h_s) - B\sqrt{h_s}\right) = (F_i - F_{is})$$

$$A\frac{d(h-h_s)}{dt} + \frac{B}{2\sqrt{h_s}}(h-h_s) = F_i - F_{is}$$

$$A\frac{d\bar{h}}{dt} + \frac{B}{2\sqrt{h_s}}\bar{h} = \bar{F_i}$$

$$A\left[s\bar{h}(s) - \cancel{\bar{h}(0)}^{0}\right] + \frac{B}{2\sqrt{h_s}}\bar{h}_s = \bar{F_i}$$

$$As\bar{h}(s) + \frac{B}{2\sqrt{h_s}}\bar{h}_s = \bar{F_i}$$

$$\bar{h}_s\left(A_s + \frac{B}{2\sqrt{h_s}}\right) = \bar{F}_i$$

$$G(s) = \frac{h(s)}{F_i} = \frac{1}{A_s + \frac{B}{2\sqrt{h_s}}}$$

$$= \frac{1}{\frac{A_s\, 2\sqrt{h_s} + B}{2\sqrt{h_s}}}$$

$$= \frac{2\sqrt{h_s}}{A_s\, 2\sqrt{h_s} + B} \quad \text{—— (4)}$$

Equ (4) is the transfer function

2. $G_p(s) = \dfrac{2}{5s+1}$

$G_p(s) = G_m(s) = 1$

$K_c = 1.5$

Using P only controller

$$y(s) = \frac{G_p(s) G_f(s) G_c(s)}{1 + G_p(s) G_f(s) G_m(s)}$$

$$y(s) = \frac{G_p(s) G_c(s)}{1 + G_p(s) G_c(s)} \times y_{sp}(s)$$

$$y(s) = \frac{{}^2/_{5s+1} \cdot 1.5}{1 + {}^2/_{5s+1} \cdot 1.5} \times \frac{3}{s}$$

$$y(s) = \frac{{}^3/_{5s+1}}{1 + {}^3/_{5s+1}} \times \frac{3}{s}$$

$$= \frac{\frac{3}{5s+1}}{\frac{5s+1+3}{5s+1}} \times \frac{3}{s}$$

$$= \frac{3}{5s+1} - \frac{5s+1+3}{5s+1} \times \frac{3}{s}$$

$$= \frac{3}{5s+4} \times \frac{3}{s}$$

$$y(s) = \frac{9}{s(5s+4)}$$

$$y(s) = \frac{9}{s(5s+4)} = \frac{A}{s} + \frac{B}{5s+4}$$

$$y(s) = \frac{9}{s(5s+4)} = \frac{A(5s+4) + Bs}{s(5s+4)}$$

$$y(s) = 9 = A(5s+9) + Bs$$

When $s = 0$

$$9 = A(5(0)+4) + B(0)$$

$$A = 9/4$$

When $s = -4/5$

$$9 = A(5(-4/5)+4) + B(-4/5)$$

$$9 = A(-4+4) + B(-4/5)$$

$$9 = -4/5 B$$

$$B = -45/4$$

$$\therefore \frac{9}{s(5s+4)} = \frac{9}{4} \cdot \frac{1}{s} - \frac{45}{4} \cdot \frac{1}{(5s+4)}$$

$$y(t) = \mathcal{L}^{-1}[y(s)] = \mathcal{L}^{-1}\left[\frac{9}{4s} - \frac{45}{4(5s+4)}\right]$$

$$\mathcal{L}^{-1}[9/4s] - \mathcal{L}^{-1}\left[\frac{45}{4(5s+1)}\right]; \mathcal{L}^{-1}[9/4s] - \mathcal{L}^{-1}\left[\frac{45}{4 \times 5(s+4/5)}\right]$$

$$\frac{9}{4}\mathcal{L}^{-1}\left[\frac{1}{s}\right] - \frac{45}{20}\mathcal{L}^{-1}\left[\frac{1}{s+4/5}\right]$$

$$y(t) = 9/4 \cdot 1 - 9/4\, e^{-4/5 t}$$

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$$y(t) = \frac{9}{4} - \frac{9}{4}e^{-4/5t}$$

$$y(t) = \frac{9}{4}\left(1 - e^{-4/5t}\right)$$