homework3

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2.1 (a) $G_v(s) > 0 \qquad G_p(s) > 0$

$G_v(s)\,G_p(s)\,G_m(s) > 0$

选反作用控制器

(b) $G_v(s) < 0 \qquad G_p(s) > 0$

$G_v(s)\,G_p(s)\,G_m(s) < 0$

选正作用控制器

2.3

$$\delta = \frac{\dfrac{160^\circ C - 140^\circ C}{200^\circ C - 100^\circ C}}{\dfrac{7mA - 3mA}{10mA - 0mA}}$$

$$= 50\%$$

2.4 (1)

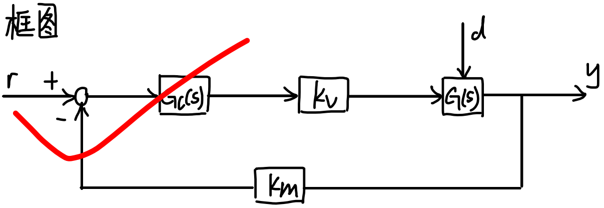
$$F\,dH = (Q_i + Q_d - Q_o)\,dt$$

有 $H = RQ_o$

可得 $FR\dfrac{dH}{dt} + H = RQ_i + RQ_d$

传递函数 $G(s) = \dfrac{R}{RFs+1}$

框图



(2) $G_c(s) = K_c = \frac{1}{\delta} = 2.5$

扰动 ΔQ_d 时

$$\frac{e_Q(s)}{Q_d(s)} = \frac{-K_m G_p(s)}{1 + G_p(s)\, G_c(s)\, K_p K_m}$$

$$e_Q(\infty) = \lim_{s \to 0} s \frac{e_Q(s)}{Q_d(s)} \frac{\Delta Q_d}{s} = \frac{-K_m R \Delta Q_d}{1 + K_c K_v K_m R}$$

$$\Delta h_Q(\infty) = \frac{e_Q(\infty)}{K_m} = -56 \times \frac{0.03}{1 - 28 \times (-2.5) \times 0.03} = -0.542 \text{ cm}$$

扰动 Δr 时:

$$\frac{e_r(s)}{r(s)} = \frac{1}{1 + K_m K_v G_c(s)\, G_p(s)}$$

$$e_r(\infty) = \lim_{s \to 0} s \frac{1}{1 + K_m K_v G_c(s)\, G_p(s)} \frac{\Delta r}{s} = \frac{\Delta r}{1 + K_m K_v K_c R}$$

$$\Delta h_r(\infty) = \frac{e_r(\infty)}{K_m} = \frac{0.5}{1 - 28 \times (-2.5) \times 0.03} = 0.162 \text{ cm}$$

(3) 可求 $K_c = \frac{1}{\delta} = \frac{5}{6}$

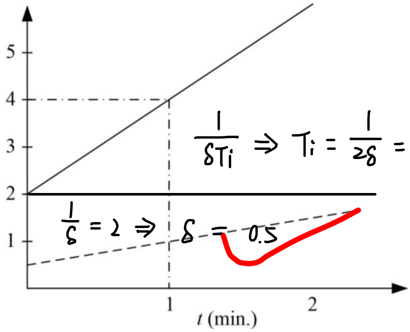
$$\Delta h_Q(\infty) = \frac{e_Q(\infty)}{K_m} = -56 \times \frac{0.5}{1 - 28 \times (-\frac{5}{6}) \times 0.03} = -0.988 \text{ cm}$$

$$\Delta h_r(\infty) = \frac{e_r(\infty)}{K_m} = \frac{0.5}{1 - 28 \times (-\frac{5}{6}) \times 0.03} = 0.294 \text{ cm}$$

比较 (2)(3) 结果发现：δ 越大，系统残差越大

(4) 改用 PI 控制器后，积分控制作用使得最终的 h 残差为 0

2.9 (1) $u(t) = \frac{1}{\delta}\left(e(t) + \frac{1}{T_i}\int_0^t e(t)\,dt\right) = \frac{1}{\delta}\left(1 + \frac{1}{T_i}t\right)$

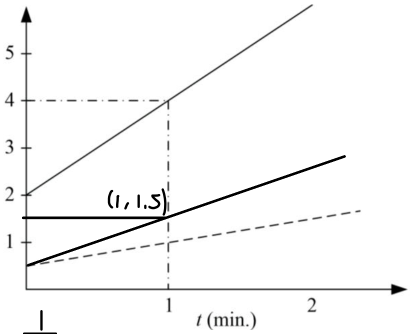


$\frac{1}{\delta T_i} \Rightarrow T_i = \frac{1}{2\delta} = 1$

$\frac{1}{\delta} = 2 \Rightarrow \delta = 0.5$

(2) $\delta' = 2 \qquad T_i' = 0.5$

$u(t) = t + 0.5$



$\frac{1}{\delta' T_i'} = 1$

$\Rightarrow T_i' = 0.5$

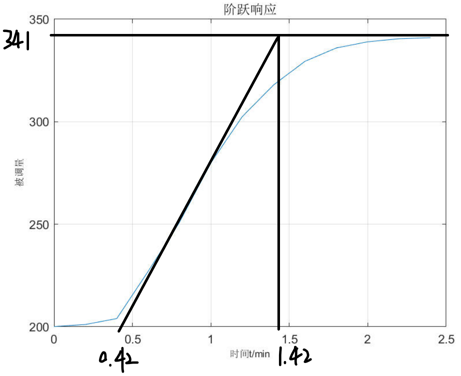
$\frac{1}{\delta'} = 0.5 \Rightarrow \delta_1 = 2$

(3) 比例控作用减弱，积分作用增强

δ影响比例作用，δ越小，比例作用越强

Ti影响积分作用，Ti越小，积分作用越强

36 (1)



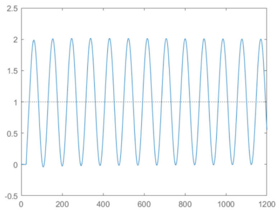
$\tau = 0.42\,\text{min}$ $\quad T = 1\,\text{min}$ $\quad K = \dfrac{341-200}{50} = 2.82$

(2) 动态参数特性法.

$$\delta = 1.1\frac{K}{T}\tau = 1.303$$

$$T_i = 3.3\tau = 1.386\,\text{min}$$

稳定边界法:



$T_{cr} = 1.52\,\text{min}$ $\quad \delta_{cr} = 0.618$

$$\delta = 2.2\,\delta_{cr} = 1.3596$$

$$T_i = 0.85\,T_{cr} = 1.292\,\text{min}$$

对比可得，两种方法结果相差较小.

3.16

$$K_cK = \left(\frac{\tau}{T}\right)^{-1} + 0.333$$

有 $K_T = \dfrac{20-4}{20-0} = 8$

$$K_c = \frac{0.6}{15} = 0.04$$

$$K_m = \frac{100}{20-4} = 6.25$$

代入得 $K_c = \dfrac{\left(\frac{\tau}{T}\right)^{-1} + 0.333}{K_T K_c K_m} = 5.1665$

$$\delta = \frac{1}{K_c} = 0.194$$

4.8 (1) 气开阀

(2) 气关阀

(3) 气开阀

4.9 (1) 气关阀

(2) 气开阀