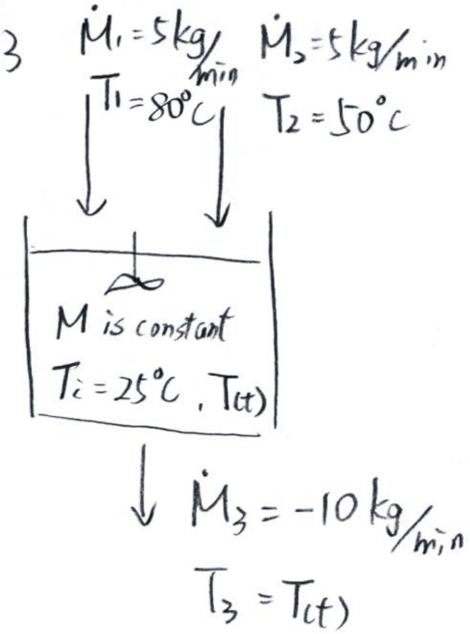
3.13



(Sol) a. Take tank as the system (open steady-state system)

$$\overset{0}{\frac{dU}{dt}}^{\;\because\text{ steady state}} = \dot{M}_1\hat{H}_1 + \dot{M}_2\hat{H}_2 + \dot{M}_3\hat{H}_3 + \overset{\text{no heat}}{\cancel{\dot{Q}}} + \overset{\text{no shaft work, no PV work}}{\cancel{\dot{W}}}$$

$$\Rightarrow \underset{kg/min}{5}\hat{H}_1 + \underset{kg/min}{5}\hat{H}_2 - \underset{kg/min}{10}\hat{H}_3 = 0$$

$$\hat{H}(T) = \underset{\text{reference temp.}}{\hat{H}(T_R)} + \int_{T_R}^{T} C_p(T)\,dT$$

, assume C_p is not a function of temp.

$$= \hat{H}(T_R) + C_p(T - T_R)$$

$$\Rightarrow 5\hat{H}(T_R) + 5C_p(80 - T_R) + 5\hat{H}(T_R) + 5C_p(50 - T_R) - 10\hat{H}(T_R) - 10C_p(T_3 - T_R) = 0$$

$$\Rightarrow T_3 = 65°C$$

b. Open Unsteady-state system

$$\frac{dU_{\text{system}}}{dt} = \dot{M}_1 \hat{H}_1 + \dot{M}_2 \hat{H}_2 + \dot{M}_3 \hat{H}_3 + \cancel{Q}^{0} + \cancel{W}^{0}$$

$$\parallel$$

$$\frac{d(M\hat{U})}{dt} = M\frac{d(\hat{U})}{dt} = MC_v\frac{dT}{dt} \rightarrow T_3$$

$$\Rightarrow 50\, C_v \frac{dT_3}{dt} = \cancel{5\hat{H}_{(T_R)}} + 5C_p(80-\cancel{T_R}) + \cancel{5\hat{H}_{(T_R)}} + 5C_p(50-\cancel{T_R}) - \cancel{10\hat{H}_{(T_R)}} - 10C_p(T_3-\cancel{T_R})$$

$$\Rightarrow 50\, C_v \frac{dT_3}{dt} = 5C_p(130) - 10C_p T_3$$

for liq. & solid $\hat{H} = \hat{U} + P\hat{V}$

$\Rightarrow d\hat{H} = d\hat{U} + Pd\hat{V} + \hat{V}dP$ → $\hat{V}$ is small for liq. & solid

$\hat{V}$ remain constant for liq. & solid.

$\Rightarrow C_p\, dT \approx C_v\, dT$

$\Rightarrow C_p \approx C_v$

$$\Rightarrow 10\frac{dT_3}{dt} = 130 - 2T_3$$

$$\Rightarrow \frac{dT_3}{dt} + \frac{1}{5}T_3 = 13 \quad \Rightarrow T_3 = C_1 e^{-\frac{1}{5}t} + C_2$$

at $t=0$. $T_3 = 25°C$

at $t \to \infty$ $T_3 = 65°C$

$$\Rightarrow \begin{cases} 25 = C_1 + C_2 \\ 65 = 0 + C_2 \end{cases} \Rightarrow C_1 = -40$$

$$\Rightarrow T_3 = -40°C\, e^{-t/5} + 65°C$$ ※