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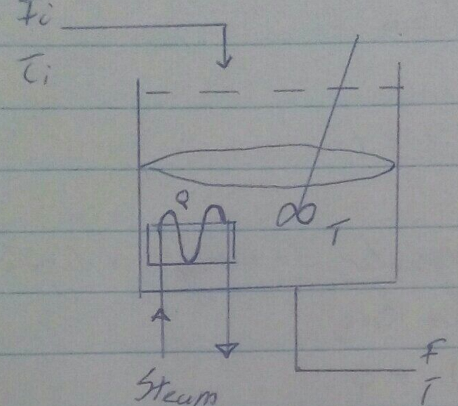
141ENG01/015

CHE 531

Assignment 1



Assuming that $Q = m_i h_s$

liquid density, ρ = 1000 kg/m^3

Liquid inlet flowrate, F_i = 0.15 m^3/min

Latent heat of Vaporization of Steam at boiling point, h_s, = 2258 kj/kg

Taking an Energy balance about the system,

$$\frac{du}{dt} = F_i\rho\left(u_i + \frac{P_i}{\rho_i}\right) - F\rho\left(u + \frac{P}{\rho}\right) + Q + W_s$$

Since Enthalpy, $H = u + PV$,

$$\frac{dH}{dt} = \frac{du}{dt} + \frac{PV}{dt}$$

$$\therefore \frac{dH}{dt} - \frac{d(PV)}{dt} = \frac{du}{dt}$$

$$\Rightarrow \frac{dH}{dt} - \frac{d(PV)}{dt} = F\rho H_i - F\rho H + Q + W_s$$

Since $\frac{d(\rho V)}{dt} = \frac{\rho dv}{dt} + \frac{V d\rho}{dt}$

Since Volume is Constant (i.e $\frac{dv}{dt} = 0$) and $\frac{d\rho}{dt}$ Can be Neglected

due to Constant density $\therefore \frac{d(\rho V)}{dt} = 0$

$$\therefore \frac{dH}{dt} = F\rho H_i - F\rho H + Q + W_s$$

Neglecting Work done by the impeller, assuming a single phase & constant heat capacity, C_p - we have,

$$V\rho C_p \frac{dT}{dt} = F\rho C_p (T_i - T) + Q$$

$$\frac{dT}{dt} = \frac{F}{V}(T_i - T) + \frac{Q}{F\rho C_p}$$

$$\frac{V}{F}\frac{dT}{dt} + T = T_i + \frac{Q}{F\rho C_p} \longrightarrow \text{Theoretical dynamic Model.}$$

Recall $Q = M_s \lambda_s$

$$\frac{3}{0.15}\frac{dT}{dt} + T = T_i + \frac{2258}{0.15 \times 1000 \times 4.181}$$

$$20\frac{dT'}{dt} + T' = T_i' + 3.6 m_s'$$

Finding the transfer function,

~~20 dT'~~

$$20(sT'(s) - T'(0)) + T'(s) = T_i'(s) + 3.6 m_s'(s)$$

$$20sT'(s) + T'(s) = T_i'(s) + 3.6 m_s'(s)$$

$$T'(s)(20s + 1) = T_i'(s) + 3.6 m_s'(s)$$

$$T'(s) = \frac{T_i'(s)}{(20s+1)} + \frac{3.6 m_s'(s)}{(20s+1)}$$