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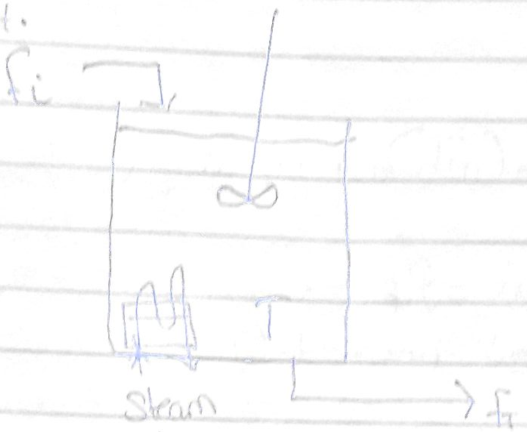
14/ENG01/004
CHE 531
Assignment.



Trying Energy Balance.

$$[U + PE + KE]_{t+\Delta t} - [U + PE + KE]_t = [H + PE + KE]_{\Delta t} - [H + PE + K]_t + Q - W_s \quad \text{--- (1)}$$

Given that: W_s = Shaft work
Q = heat (total)
KE = kinetic Energy
PE = Potential Energy

Assuming
$W_s = 0$ (since steady state)
$PE = 0$ (no change in height)
$KE = 0$ (no change in velocity)

$$[U_{system}]_{t+\Delta t} - [U_{sys}]_t = H_{in}\Delta t - W_{out}\Delta t + Q\Delta t$$

limiting $t \to 0$ and ~~making~~ dy differentiating U with respect to t.

$$\frac{dU}{dt} = H_{in} - H_{out} + Q \quad \text{--- (2)}$$

Now from first law of thermodynamics.

$U = H + PV$

$U_{system} = H_{syst} - (PV)_{sys}$

$$\frac{dU}{dt} = \frac{dH}{dt} - \cancel{\frac{PdV}{dt}}^{0} - \cancel{\frac{VdP}{dt}}^{0}$$

$$\therefore \frac{dU}{dt} = \frac{dH}{dt} \quad \text{--- (3)}$$

Substitute eqn (3) into (2)

$$\frac{dH}{dt} = \dot{H}_{in} - \dot{H}_{out} + Q$$

$\dot{H} = \dot{m}h$

$m = \rho v \quad \dot{m} = \rho f$

$$\therefore \frac{d(m_{sys})}{dt} = (\dot{m}h)_{in} - (\dot{m}h)_{out} + Q$$

Replace $m = \rho v$ and $\dot{m} = \rho f$

$$\therefore \frac{d(\rho v h)}{dt} = \rho f h_{in} - \rho f h_{out} + Q$$

$$\rho v \frac{dh}{dt} = \rho f h_{in} - \rho f h_{out} + Q$$

Given that $Q = \dot{m}_s \lambda_s$, $h = C_p dT$

$$\rho v C_p \frac{dT}{dt} = f \rho c_p \left.\int_{T_0}^{T} dT\right]_{in} - f \rho c_p \left.\int_{T_0}^{T} dT\right]_{out} + \dot{m}_s \lambda_s$$

$$\therefore \rho v C_p \frac{dT}{dt} = f \rho C_p [T_1 - T_0] - f \rho c_p [T - T_0] + \dot{m}_s \lambda_s$$

Therefore $\frac{\rho v C_p dT}{f \rho C_p dT} = \frac{f \rho c_p (T_1 - T_0)}{f \rho c_p} - \frac{f \rho c_p [T - T_0]}{f \rho c_p} + \frac{\dot{m}_s \lambda_s}{f \rho c_p}$

$$\frac{V}{f} \frac{dT}{dt} = [T_1 - T_0] - [T - T_0] + \frac{\dot{m}_s \lambda_s}{f \rho c_p}$$

$$\frac{V}{f} \frac{dT}{dt} = T_1 - \cancel{T_0} - T + \cancel{T_0} + \frac{\dot{m}_s \lambda_s}{f \rho c_p}$$

$$\frac{V}{f} \frac{dT}{dt} = T_1 - T + \frac{\dot{m}_s \lambda_s}{f \rho c_p}$$

$$\frac{V}{f} \frac{dT}{dt} + T = T_1 + \frac{\dot{m}_s \lambda_s}{f \rho c_p}$$

Putting in values.

$\rho = 1000\ kg/m^3$, $C_p = 4.181\ kJ/kg°C$, $f_1 = 0.15\ m^3/min$, $V = 3m^3$

$\lambda_s = 2258\ kJ/kg$.

$$\therefore \frac{3}{0.15} \frac{dT}{dt} + T = T_1 + \frac{\dot{m}_s \cdot 2258}{0.15 \times 1000 \times 4.181}$$

$$2.0 \frac{dT}{dt} + T = T_1 + \dot{m}_s 3.6$$ } deviation variable.

The deviation variable = Dynamic model - Steady state model

Transfer function

$\frac{dT}{dt} = sT(s) - T(0)$

$T = T(s)$

Putting in deviation variable.

$2.0[sT'(s) - T'(0)] + T'(s) = T_i'(s) + 3.6\dot{m}'_s(s)$

$2.0sT'(s) + T'(s) = T_i'(s) + 3.6\dot{m}'s(s)$

factorising $T'(s)$ and making $T'(s)$ subject of the formular

$T'(s)(2.0s+1) = T_i'(s) + 3.6\dot{m}s(s)$

$T'(s) = T_i'(s) + 3.6\ \dot{m}s(s)$