ANNOUNCED QUIZ #10 – ME 3030 — Section 001 – Fall 2025

SOLUTION

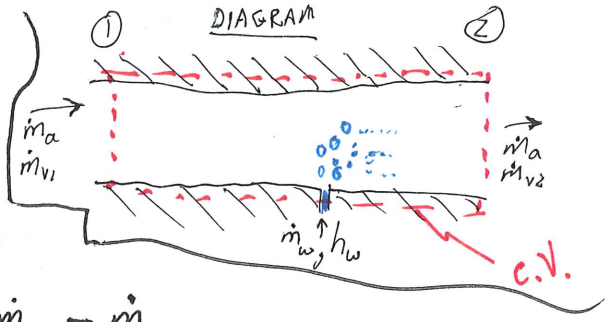
NAME: _____

This is a closed book quiz, no calculator quiz. An unsigned honors pledge will result in a zero.

1. Moist air enters a perfectly insulated duct at state 1 and exits at state 2. Between the duct inlet and outlet, liquid water having an enthalpy h_w is sprayed into the duct at a liquid flow rate $\dot{m}_w$ and immediately evaporates. Using the conservation of energy equation for a control volume,

$$\frac{dE_{C.V.}}{dt} = \dot{Q}_{C.V.} - \dot{W}_{C.V.} + \sum_i \dot{m}_i\left(h_i + \frac{V_i^2}{2} + gz_i\right) - \sum_e \dot{m}_e\left(h_e + \frac{V_e^2}{2} + gz_e\right) \qquad (1)$$

and the equation for the humidity ratio: $\omega = m_v/m_a = \dot{m}_v/\dot{m}_a$, develop an equation for ω_2 solely in terms of $h_{a1}, h_{a2}, h_w, h_{v1}, h_{v2}, \omega_1$



GIVEN: C.O.E. and ω equations

FIND: $\omega_2 = f(h_{a1}, h_{a2}, h_w, h_{v1}, h_{v2}, \omega_1)$

ASSUME: Steady-state conditions; no KE or PE effects.

ANALYSIS: $\frac{dE}{dt} = \dot{Q} - \dot{W} + \sum_i \dot{m}_i\left(h_i + \frac{V_i^2}{2} + gz_i\right) - \sum_e \dot{m}_e\left(h_e + \frac{V_e^2}{2} + gz_e\right)$

S.S; adiabatic; no shaft; No KE or PE

C.O.E. → $\sum_i \dot{m}_i h_i = \sum_e \dot{m}_e h_e$

$\dot{m}_a h_{a1} + \dot{m}_{v1} h_{v1} + \dot{m}_w h_w = \dot{m}_a h_{a2} + \dot{m}_{v2} h_{v2}$

C of Mass: $\dot{m}_{a1} = \dot{m}_{a2} = \dot{m}_a$

$\dot{m}_{v1} + \dot{m}_w = \dot{m}_{v2} \rightarrow \dot{m}_w = \dot{m}_{v2} - \dot{m}_{v1}$

C of Mass

Divide by $\dot{m}_a$

$h_{a1} + \omega_1 h_{v1} + \frac{\dot{m}_{v2} - \dot{m}_{v1}}{\dot{m}_a} h_w = h_{a2} + \omega_2 h_{v2} \rightarrow h_{a1} + \omega_1 h_{v1} + (\omega_2 - \omega_1) h_w = h_{a2} + \omega_2 h_{v2}$

$h_{a1} + \omega_1 h_{v1} + \omega_2 h_w - \omega_1 h_w = h_{a2} + \omega_2 h_{v2}$

Separate ω_2 terms

$\omega_2 h_{v2} - \omega_2 h_w = h_{a1} + \omega_1 h_{v1} - \omega_1 h_w - h_{a2}$

$\omega_2 (h_{v2} - h_w) = h_{a1} + \omega_1 (h_{v1} - h_w) - h_{a2}$

$$\omega_2 = \frac{h_{a1} + \omega_1 (h_{v1} - h_w) - h_{a2}}{(h_{v2} - h_w)}$$

← ANS.

I HAVE NEITHER PROVIDED OR RECEIVED HELP DURING THIS QUIZ.

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SIGNATURE