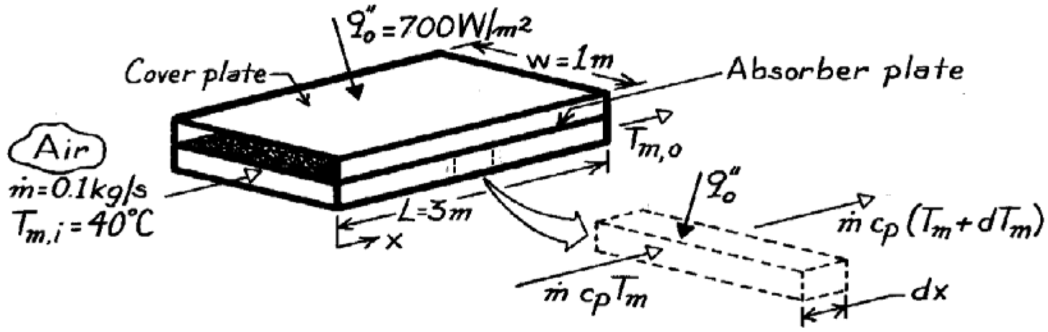
PROBLEM 8.17

KNOWN: Surface heat flux for air flow through a rectangular channel.

FIND: (a) Differential equation describing variation in air mean temperature, (b) Air outlet temperature for prescribed conditions.

SCHEMATIC:



ASSUMPTIONS: (1) Ideal gas with negligible viscous dissipation and pressure variation, (2) No heat loss through bottom of channel, (3) Uniform heat flux at top of channel.

PROPERTIES: *Table A-4*, Air (T ≈ 50°C, 1 atm): c_p = 1008 J/kg·K.

ANALYSIS: (a) For the differential control volume about the air,

$$\dot{E}_{in} = \dot{E}_{out}$$

$$\dot{m}\, c_p\, T_m + q_o''\,(w \cdot dx) = \dot{m}\, c_p\,(T_m + d\,T_m)$$

$$\frac{d\,T_m}{dx} = \frac{q_o'' \cdot w}{\dot{m}\, c_p}$$

Separating and integrating between the limits of x = 0 and x, find

$$T_m(x) = T_{m,i} + \frac{q_o''(w \cdot x)}{\dot{m}\, c_p}$$

$$T_{m,o} = T_{m,i} + \frac{q_o''(w \cdot L)}{\dot{m}\, c_p}. \qquad <$$

(b) Substituting numerical values, the air outlet temperature is

$$T_{m,o} = 40^\circ C + \frac{\left(700\ W/m^2\right)(1 \times 3)\,m^2}{0.1\ kg/s\ \left(1008\ J/kg \cdot K\right)}$$

$$T_{m,o} = 60.8^\circ C. \qquad <$$

COMMENTS: Due to increasing heat loss with increasing T_m, the net flux q_o'' will actually decrease slightly with increasing x.