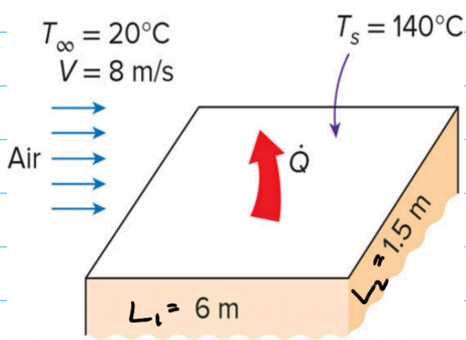
Trevor Swan **ECHE225: QUIZ #12 // 12.04.24**

$P_{atm} = 83.4$ kPa ← From elevation = 1610m



<u>Given</u>

$T_\infty = 20°C$

$U_\infty = 8.00\ m/s$

$T_s = 140°C$

$T_{film} = T_f = \frac{140+20}{2} = 80°C$

$L_1 = 6m$

$L_2 = 1.5m$

<u>Given Properties of air @ 1atm, T_f</u>

$\rho = 0.9994\ \frac{kg}{m^3}$

$k = 0.02953\ \frac{W}{mK}$

$\mu = 2.096 \times 10^{-5}\ \frac{kg}{m \cdot s}$

$P_r = 0.7154$

→ Assume Ideal Gas

$1atm = 101.325\ kPa$

$P_{atm} = 83.4\ kPa$

2. $PV = m\bar{R}T$

$P_1 = \rho_1 \bar{R} T$

$\frac{P_1}{\rho_1} = \frac{P_2}{\rho_2}$ → $\rho_2 = \frac{P_2 \rho_1}{P_1} = \frac{(83.4 kPa)(0.994 \frac{kg}{m^3})}{101.325\ kPa} = 0.823\ \frac{kg}{m^3}$

$$\boxed{\rho_2 = 0.823\ \frac{kg}{m^3}}$$

3. Rate of heat transfer (kW) along $L_1 = 6m$

$Re_L = \frac{\rho U_\infty L}{\mu} = \frac{(0.823 \frac{kg}{m^3})(8\ m/s)(6m)}{2.096 \times 10^{-5} \frac{kg}{m \cdot s}} = 1884732.8 = 18.84 \times 10^5 > 5 \times 10^5$ turbulent

$Nu_L = 0.037 \cdot (18.84 \times 10^5)^{4/5} \cdot (0.7154)^{1/3} = 3465.63$

$h = \frac{Nu_L\ k_{fluid}}{L} = \frac{(3465.63)(0.02953 \frac{W}{mK})}{6m} = 17.057\ \frac{W}{m^2K}$

$\dot{Q}_{conv} = \frac{h \Delta T}{A_s} = \frac{(17.057 \frac{W}{m^2K})(120°C)}{(6m \cdot 1.5m)} = 227.42\ W$ $\boxed{\dot{Q}_{conv} = 0.23\ kW}$

4. Rate of heat transfer (kW) along $L_2 = 1.5\ m$

$Re_L = \frac{(0.823 \frac{kg}{m^3})(8\ m/s)(1.5m)}{2.096 \times 10^{-5} \frac{kg}{m \cdot s}} = 471183 = 4.7 \times 10^5 < 5 \times 10^5$ laminar

$Nu_L = 0.664(4.7 \times 10^5)^{1/2}(0.7154)^{1/3} = 407.13$

$h = \frac{Nu_L\ k_{fluid}}{L} = \frac{(407.13)(0.02953 \frac{W}{mK})}{1.5m} = 6.015\ \frac{W}{m^2K}$

$\dot{Q}_{conv} = \frac{h \Delta T}{A_s} = \frac{(6.015 \frac{W}{m^2K})(120°C)}{(6m \cdot 1.5m)} = 106.867\ W$ $\boxed{\dot{Q}_{conv} = 0.11\ kW}$