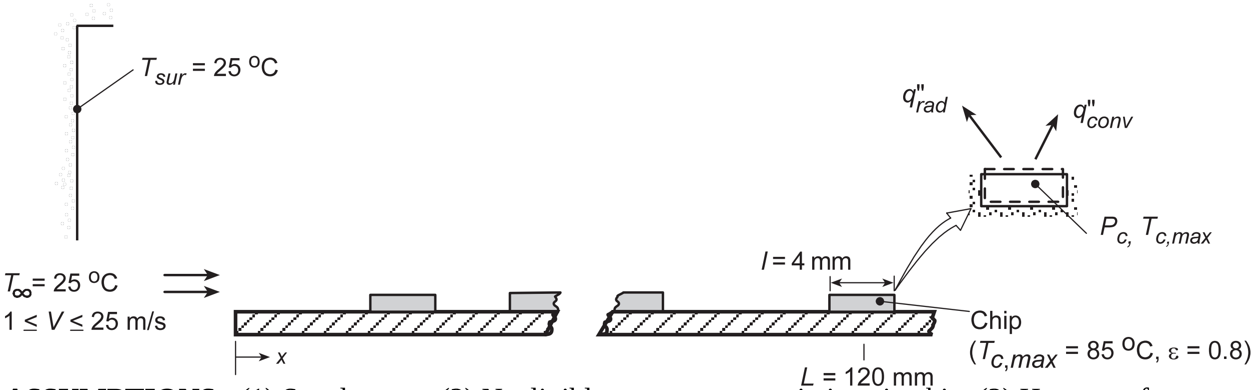
# PROBLEM 6.41

**KNOWN:** Location and dimensions of computer chip on a circuit board. Form of the convection correlation. Maximum allowable chip temperature and surface emissivity. Temperature of cooling air and surroundings.

**FIND:** Effect of air velocity on maximum power dissipation, first without and then with consideration of radiation effects.

**SCHEMATIC:**



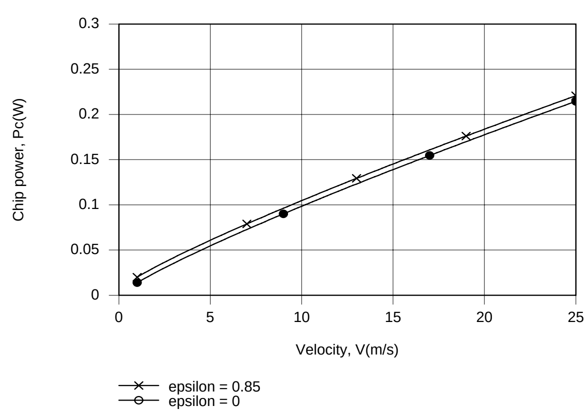

**ASSUMPTIONS:** (1) Steady-state, (2) Negligible temperature variations in chip, (3) Heat transfer exclusively from the top surface of the chip, (4) The local heat transfer coefficient at x = L provides a good approximation to the average heat transfer coefficient for the chip surface.

**PROPERTIES:** *Table A.4*, air ($\overline{T} = (T_\infty + T_c)/2$ = 328 K): $\nu = 18.71 \times 10^{-6}$ m$^2$/s, k = 0.0284 W/m·K, Pr = 0.703.

**ANALYSIS:** Performing an energy balance for a control surface about the chip, we obtain $P_c = q_{conv} + q_{rad}$, where $q_{conv} = \overline{h}A_s(T_c - T_\infty)$, $q_{rad} = h_r A_s(T_c - T_{sur})$, and $h_r = \varepsilon\sigma(T_c + T_{sur})(T_c^2 + T_{sur}^2)$. With $\overline{h} \approx h_L$, the convection coefficient may be determined from the correlation provided in Problem 6.39 ($Nu_L = 0.04\, Re_L^{0.85}\, Pr^{1/3}$). Hence,

$$P_c = \ell^2\left[0.04(k/L)Re_L^{0.85}\,Pr^{1/3}(T_c - T_\infty) + \varepsilon\sigma(T_c + T_{sur})\left(T_c^2 + T_{sur}^2\right)(T_c - T_{sur})\right]$$

where $Re_L = VL/\nu$. Computing the right side of this expression for ε = 0 and ε = 0.85, we obtain the following results.




Since $h_L$ increases as $V^{0.85}$, the chip power must increase with V in the same manner. Radiation exchange increases $P_c$ by a fixed, but small (6 mW) amount. While $h_L$ varies from 14.5 to 223 W/m$^2$·K over the prescribed velocity range, $h_r$ = 6.5 W/m$^2$·K is a constant, independent of V.

**COMMENTS:** Alternatively, $\overline{h}$ could have been evaluated by integrating $h_x$ over the range 118 ≤ x ≤ 122 mm to obtain the appropriate average. However, the value would be extremely close to $h_{x=L}$.