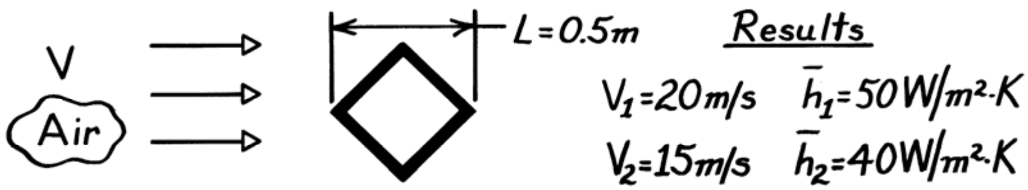
PROBLEM 6.29

KNOWN: Experimental measurements of the heat transfer coefficient for a square bar in cross flow.

FIND: (a) $\bar{h}$ for the condition when L = 1m and V = 15m/s, (b) $\bar{h}$ for the condition when L = 1m and V = 30m/s, (c) Effect of defining a side as the characteristic length.

SCHEMATIC:



ASSUMPTIONS: (1) Functional form $\overline{Nu} = CRe^m Pr^n$ applies with C, m, n being constants, (2) Constant properties.

ANALYSIS: (a) For the experiments and the condition L = 1m and V = 15m/s, it follows that Pr as well as C, m, and n are constants. Hence

$$\bar{h}L \propto (VL)^m .$$

Using the experimental results, find m. Substituting values

$$\frac{\bar{h}_1 L_1}{\bar{h}_2 L_2} = \left[\frac{V_1 L_1}{V_2 L_2}\right]^m \qquad \frac{50 \times 0.5}{40 \times 0.5} = \left[\frac{20 \times 0.5}{15 \times 0.5}\right]^m$$

giving m = 0.782. It follows then for L = 1m and V = 15m/s,

$$\bar{h} = \bar{h}_1 \frac{L_1}{L}\left[\frac{V \cdot L}{V_1 \cdot L_1}\right]^m = 50 \frac{W}{m^2 \cdot K} \times \frac{0.5}{1.0}\left[\frac{15 \times 1.0}{20 \times 0.5}\right]^{0.782} = 34.3 W/m^2 \cdot K. \qquad <$$

(b) For the condition L = 1m and V = 30m/s, find

$$\bar{h} = \bar{h}_1 \frac{L_1}{L}\left[\frac{V \cdot L}{V_1 \cdot L_1}\right]^m = 50 \frac{W}{m^2 \cdot K} \times \frac{0.5}{1.0}\left[\frac{30 \times 1.0}{20 \times 0.5}\right]^{0.782} = 59.0 W/m^2 \cdot K. \qquad <$$

(c) If the characteristic length were chosen as a side rather than the diagonal, the value of C would change. However, the coefficients m and n would not change.

COMMENTS: The foregoing Nusselt number relation is used frequently in heat transfer analysis, providing appropriate scaling for the effects of length, velocity, and fluid properties on the heat transfer coefficient.