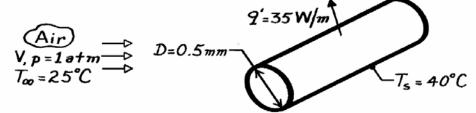
## PROBLEM 7.49

KNOWN: Temperature and heat dissipation in a wire of diameter D.

FIND: (a) Expression for flow velocity over wire, (b) Velocity of airstream for prescribed conditions.

## **SCHEMATIC:**



**ASSUMPTIONS:** (1) Steady-state conditions, (2) Uniform wire temperature, (3) Negligible radiation.

**PROPERTIES:** Table A-4, Air ( $T_{\infty} = 298 \text{ K}$ , 1 atm):  $v = 15.8 \times 10^{-6} \text{ m}^2/\text{s}$ , k = 0.0262 W/m·K, Pr = 0.71; ( $T_S = 313 \text{ K}$ , 1 atm): Pr = 0.705.

ANALYSIS: (a) The rate of heat transfer per unit cylinder length is

$$q' = (q/L) = \overline{h}(\pi D) (T_s - T_\infty)$$

where, from the Zhukauskas relation, with Pr ≈ Pr<sub>s</sub>,

$$\overline{h} = \frac{k}{D} C Re_D^m Pr^n = \frac{k}{D} C \left(\frac{VD}{V}\right)^m Pr^n$$

Hence,

$$V = \left[ \frac{q'}{(k/D)C \operatorname{Pr}^{n}(\pi D) (T_{s} - T_{\infty})} \right]^{1/m} \left( \frac{\nu}{D} \right).$$

(b) Assuming  $(10^3 < \text{Re}_D < 2 \times 10^5)$ , C = 0.26, m = 0.6 from Table 7.3. Hence,

$$V = \left[\frac{35 \text{ W/m}}{0.0262 \text{ W/m} \cdot \text{K} \times 0.26 \big(0.71\big)^{0.37} \, \pi \big(40 - 25\big)^{\circ} \, \text{C}}\right]^{1/0.6} \left(\frac{15.8 \times 10^{-6} \, \text{m}^2 \, / \text{s}}{5 \times 10^{-4} \text{m}}\right)$$

$$V = 97 \text{ m/s}.$$

To verify the assumption of the Reynolds number range, calculate

$$Re_D = \frac{VD}{v} = \frac{97 \text{ m/s} \left(5 \times 10^{-4} \text{m}\right)}{15.8 \times 10^{-6} \text{m}^2/\text{s}} = 3074.$$

Hence the assumption was correct.

**COMMENTS:** The major uncertainty associated with using this method to determine V is that associated with use of the correlation for  $\overline{Nu}_D$ .

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