

12-87 A cylindrical electronic component mounted on a circuit board is cooled by air flowing across it. The surface temperature of the component is to be determined.

Assumptions **1** Steady operating conditions exist. **2** Radiation effects are negligible. **3** Air is an ideal gas with constant properties. **4** The local atmospheric pressure is 1 atm.

Properties We assume the film temperature to be 50°C. The properties of air at 1 atm and at this temperature are (Table A-22)

$$k = 0.02735 \text{ W/m} \cdot ^\circ\text{C}$$

$$\nu = 1.798 \times 10^{-5} \text{ m}^2/\text{s}$$

$$\text{Pr} = 0.7228$$

Analysis The Reynolds number is

$$\text{Re} = \frac{VD}{\nu} = \frac{(240/60 \text{ m/s})(0.003 \text{ m})}{1.798 \times 10^{-5} \text{ m}^2/\text{s}} = 667.4$$

The proper relation for Nusselt number corresponding to this Reynolds number is

$$\begin{aligned} \text{Nu} = \frac{hD}{k} &= 0.3 + \frac{0.62 \text{Re}^{0.5} \text{Pr}^{1/3}}{\left[1 + (0.4/\text{Pr})^{2/3}\right]^{1/4}} \left[1 + \left(\frac{\text{Re}}{282,000}\right)^{5/8}\right]^{4/5} \\ &= 0.3 + \frac{0.62(667.4)^{0.5} (0.7228)^{1/3}}{\left[1 + (0.4/0.7228)^{2/3}\right]^{1/4}} \left[1 + \left(\frac{667.4}{282,000}\right)^{5/8}\right]^{4/5} = 13.17 \end{aligned}$$

The heat transfer coefficient is

$$h = \frac{k}{D} \text{Nu} = \frac{0.02735 \text{ W/m} \cdot ^\circ\text{C}}{0.003 \text{ m}} (13.17) = 120.0 \text{ W/m}^2 \cdot ^\circ\text{C}$$

Then the surface temperature of the component becomes

$$A_s = \pi DL = \pi(0.003 \text{ m})(0.018 \text{ m}) = 0.0001696 \text{ m}^2$$

$$\dot{Q} = hA_s(T_s - T_\infty) \longrightarrow T_s = T_\infty + \frac{\dot{Q}}{hA} = 35^\circ\text{C} + \frac{0.4 \text{ W}}{(120.0 \text{ W/m}^2 \cdot ^\circ\text{C})(0.0001696 \text{ m}^2)} = \mathbf{54.6^\circ\text{C}}$$

The film temperature is $(54.6 + 35)/2 = 44.8^\circ\text{C}$, which is sufficiently close to the assumed value of 50°C . Therefore, there is no need to repeat calculations.

