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)

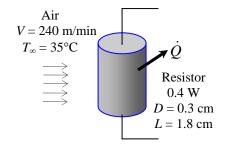
$$k = 0.02735 \text{ W/m.}^{\circ}\text{C}$$

 $v = 1.798 \times 10^{-5} \text{ m}^{2}/\text{s}$
 $Pr = 0.7228$

Analysis The Reynolds number is

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

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



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

The heat transfer coefficient is

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

Then the surface temperature of the component becomes

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

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

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