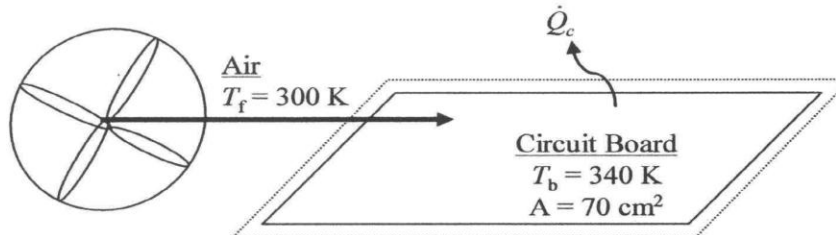


PROBLEM 2.46

KNOWN: A fan forces air to flow over a circuit board to avoid overheating.

FIND: Largest and smallest heat transfer rates associated with this forced convection.

SCHEMATIC AND GIVEN DATA:



ENGINEERING MODEL:

1. The circuit board is the system.
2. The system is at steady state.

ANALYSIS:

Newton's Law of Cooling is $\dot{Q}_c = hA(T_b - T_f)$, where \dot{Q}_c is the rate of cooling heat transfer, h is the convection heat transfer coefficient, A is area of the surface, T_b is temperature of the surface, and T_f is temperature of the flowing fluid (air).

From Table 2.1 for forced convection using gases, the largest and smallest values for the convection heat transfer coefficient are

(Largest) $h = 250 \text{ W}/(\text{m}^2 \cdot \text{K})$

(Smallest) $h = 25 \text{ W}/(\text{m}^2 \cdot \text{K})$

Substituting into Newton's Law of Cooling yields

$$\dot{Q}_c = \left(250 \frac{\text{W}}{\text{m}^2 \cdot \text{K}} \right) \left(70 \text{ cm}^2 \right) \left| \frac{\text{m}^2}{(100 \text{ cm})^2} \right| (340 \text{ K} - 300 \text{ K}) = \underline{70 \text{ W (largest heat transfer rate)}}$$

and

$$\dot{Q}_c = \left(25 \frac{\text{W}}{\text{m}^2 \cdot \text{K}} \right) \left(70 \text{ cm}^2 \right) \left| \frac{\text{m}^2}{(100 \text{ cm})^2} \right| (340 \text{ K} - 300 \text{ K}) = \underline{7 \text{ W (smallest heat transfer rate)}}$$