

5-106 A computer is cooled by a fan blowing air through the case of the computer. The required flow rate of the air and the fraction of the temperature rise of air that is due to heat generated by the fan are to be determined.

Assumptions **1** Steady flow conditions exist. **2** Air is an ideal gas with constant specific heats. **3** The pressure of air is 1 atm. **4** Kinetic and potential energy changes are negligible

Properties The specific heat of air at room temperature is $c_p = 1.005 \text{ kJ/kg}\cdot^\circ\text{C}$ (Table A-2).

Analysis (a) We take the air space in the computer as the system, which is a control volume. The energy balance for this steady-flow system can be expressed in the rate form as

$$\underbrace{\dot{E}_{\text{in}} - \dot{E}_{\text{out}}}_{\text{Rate of net energy transfer by heat, work, and mass}} = \underbrace{\Delta \dot{E}_{\text{system}}}_{\text{Rate of change in internal, kinetic, potential, etc. energies}} \stackrel{\text{no (steady)}}{=} 0$$

$$\dot{E}_{\text{in}} = \dot{E}_{\text{out}}$$

$$\dot{Q}_{\text{in}} + \dot{W}_{\text{in}} + \dot{m}h_1 = \dot{m}h_2 \quad (\text{since } \Delta ke \cong \Delta pe \cong 0)$$

$$\dot{Q}_{\text{in}} + \dot{W}_{\text{in}} = \dot{m}c_p(T_2 - T_1)$$



Noting that the fan power is 25 W and the 8 PCBs transfer a total of 80 W of heat to air, the mass flow rate of air is determined to be

$$\dot{Q}_{\text{in}} + \dot{W}_{\text{in}} = \dot{m}c_p(T_e - T_i) \rightarrow \dot{m} = \frac{\dot{Q}_{\text{in}} + \dot{W}_{\text{in}}}{c_p(T_e - T_i)} = \frac{(8 \times 10) \text{ W} + 25 \text{ W}}{(1005 \text{ J/kg}\cdot^\circ\text{C})(10^\circ\text{C})} = \mathbf{0.0104 \text{ kg/s}}$$

(b) The fraction of temperature rise of air that is due to the heat generated by the fan and its motor can be determined from

$$\dot{Q} = \dot{m}c_p \Delta T \rightarrow \Delta T = \frac{\dot{Q}}{\dot{m}c_p} = \frac{25 \text{ W}}{(0.0104 \text{ kg/s})(1005 \text{ J/kg}\cdot^\circ\text{C})} = 2.4^\circ\text{C}$$

$$f = \frac{2.4^\circ\text{C}}{10^\circ\text{C}} = 0.24 = \mathbf{24\%}$$