

**8-46** Saturated Refrigerant-134a vapor at 160 kPa is compressed steadily by an adiabatic compressor. The minimum power input to the compressor is to be determined.

**Assumptions 1** This is a steady-flow process since there is no change with time. **2** Kinetic and potential energy changes are negligible. **3** The device is adiabatic and thus heat transfer is negligible.

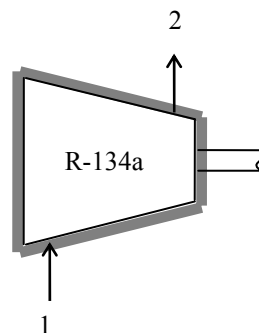
**Analysis** The power input to an adiabatic compressor will be a minimum when the compression process is reversible. For the reversible adiabatic process we have  $s_2 = s_1$ . From the refrigerant tables (Tables A-11 through A-13),

$$\left. \begin{array}{l} P_1 = 160 \text{ kPa} \\ \text{sat. vapor} \end{array} \right\} \begin{array}{l} \nu_1 = \nu_{g@160 \text{ kPa}} = 0.12348 \text{ m}^3/\text{kg} \\ h_1 = h_{g@160 \text{ kPa}} = 241.11 \text{ kJ/kg} \\ s_1 = s_{g@160 \text{ kPa}} = 0.9419 \text{ kJ/kg} \cdot \text{K} \end{array}$$

$$\left. \begin{array}{l} P_2 = 900 \text{ kPa} \\ s_2 = s_1 \end{array} \right\} h_2 = 277.06 \text{ kJ/kg}$$

Also,

$$\dot{m} = \frac{\dot{V}_1}{\nu_1} = \frac{2 \text{ m}^3/\text{min}}{0.12348 \text{ m}^3/\text{kg}} = 16.20 \text{ kg/min} = 0.27 \text{ kg/s}$$



There is only one inlet and one exit, and thus  $\dot{m}_1 = \dot{m}_2 = \dot{m}$ . We take the compressor as the system, which is a control volume since mass crosses the boundary. The energy balance for this steady-flow system can be expressed in the rate form as

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

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

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

$$\dot{W}_{\text{in}} = \dot{m}(h_2 - h_1)$$

Substituting, the minimum power supplied to the compressor is determined to be

$$\dot{W}_{\text{in}} = (0.27 \text{ kg/s})(277.06 - 241.11) \text{ kJ/kg} = \mathbf{9.71 \text{ kW}}$$