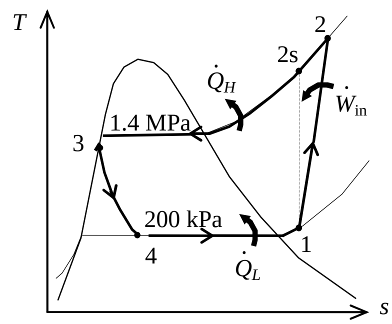
11-26 A vapor-compression refrigeration cycle with refrigerant-134a as the working fluid is considered. The rate of cooling, the power input, and the COP are to be determined. Also, the same parameters are to be determined if the cycle operated on the ideal vapor-compression refrigeration cycle between the same pressure limits.

Assumptions **1** Steady operating conditions exist. **2** Kinetic and potential energy changes are negligible.

Analysis (a) From the refrigerant-134a tables (Tables A-11 through A-13)

$$T_{\text{sat@200 kPa}} = -10.1°\text{C}$$

$$\left.\begin{array}{l} P_1 = 200 \text{ kPa} \\ T_1 = -10.1 + 10.1 = 0°\text{C} \end{array}\right\} \begin{array}{l} h_1 = 253.05 \text{ kJ/kg} \\ s_1 = 0.9698 \text{ kJ/kg}\cdot\text{K} \end{array}$$



$$\left.\begin{array}{l} P_2 = 1400 \text{ kPa} \\ s_1 = s_1 \end{array}\right\} h_{2s} = 295.90 \text{ kJ/kg}$$

$$T_{\text{sat@1400 kPa}} = 52.4°\text{C}$$

$$\left.\begin{array}{l} P_3 = 1400 \text{ kPa} \\ T_3 = 52.4 - 4.4 = 48°\text{C} \end{array}\right\} h_3 \cong h_{f@48°\text{C}} = 120.39 \text{ kJ/kg}$$

$$h_4 = h_3 = 120.39 \text{ kJ/kg}$$

$$\eta_C = \frac{h_{2s} - h_1}{h_2 - h_1}$$

$$0.88 = \frac{295.90 - 253.05}{h_2 - 253.05} \longrightarrow h_2 = 301.74 \text{ kJ/kg}$$

$$\dot{Q}_L = \dot{m}(h_1 - h_4) = (0.025 \text{ kg/s})(253.05 - 120.39) = \mathbf{3.317 \text{ kW}}$$

$$\dot{Q}_H = \dot{m}(h_2 - h_3) = (0.025 \text{ kg/s})(301.74 - 120.39) = \mathbf{4.534 \text{ kW}}$$

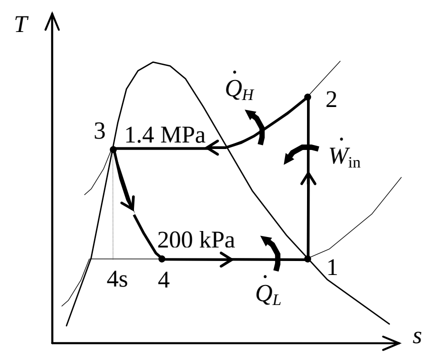
$$\dot{W}_{\text{in}} = \dot{m}(h_2 - h_1) = (0.025 \text{ kg/s})(301.74 - 253.05) = \mathbf{1.217 \text{ kW}}$$

$$\text{COP} = \frac{\dot{Q}_L}{\dot{W}_{\text{in}}} = \frac{3.317 \text{ kW}}{1.217 \text{ kW}} = \mathbf{2.725}$$

(b) Ideal vapor-compression refrigeration cycle solution

From the refrigerant-134a tables (Tables A-11 through A-13)

$$\left.\begin{array}{l} P_1 = 200 \text{ kPa} \\ x_1 = 1 \end{array}\right\} \begin{array}{l} h_1 = 244.46 \text{ kJ/kg} \\ s_1 = 0.9377 \text{ kJ/kg}\cdot\text{K} \end{array}$$



$$\left.\begin{array}{l} P_2 = 1400 \text{ kPa} \\ s_1 = s_1 \end{array}\right\} h_2 = 285.08 \text{ kJ/kg}$$

$$\left.\begin{array}{l} P_3 = 1400 \text{ kPa} \\ x_3 = 0 \end{array}\right\} h_3 = 127.22 \text{ kJ/kg}$$

$$h_4 = h_3 = 127.22 \text{ kJ/kg}$$

$$\dot{Q}_L = \dot{m}(h_1 - h_4) = (0.025 \text{ kg/s})(244.46 - 127.22) = \mathbf{3.931 \text{ kW}}$$

$$\dot{Q}_H = \dot{m}(h_2 - h_3) = (0.025 \text{ kg/s})(285.08 - 127.22) = \mathbf{3.947 \text{ kW}}$$

$$\dot{W}_{\text{in}} = \dot{m}(h_2 - h_1) = (0.025 \text{ kg/s})(285.08 - 244.46) = \mathbf{1.016 \text{ kW}}$$

$$\text{COP} = \frac{\dot{Q}_L}{\dot{W}_{\text{in}}} = \frac{3.931 \text{ kW}}{1.016 \text{ kW}} = \mathbf{2.886}$$

Discussion The cooling load increases by 18.5% while the COP increases by 5.9% when the cycle operates on the ideal vapor-compression cycle.

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