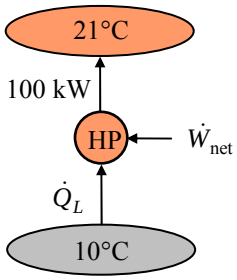
8-29 A reversible heat pump with specified reservoir temperatures is considered. The entropy change of two reservoirs is to be calculated and it is to be determined if this heat pump satisfies the increase in entropy principle.

Assumptions The heat pump operates steadily.

Analysis Since the heat pump is completely reversible, the combination of the coefficient of performance expression, first Law, and thermodynamic temperature scale gives



$$\text{COP}_{\text{HP,rev}} = \frac{1}{1 - T_L / T_H} = \frac{1}{1 - (283\,\text{K})/(294\,\text{K})} = 26.73$$

The power required to drive this heat pump, according to the coefficient of performance, is then

$$\dot{W}_{\text{net,in}} = \frac{\dot{Q}_H}{\text{COP}_{\text{HP,rev}}} = \frac{100\,\text{kW}}{26.73} = 3.741\,\text{kW}$$

According to the first law, the rate at which heat is removed from the low-temperature energy reservoir is

$$\dot{Q}_L = \dot{Q}_H - \dot{W}_{\text{net,in}} = 100\,\text{kW} - 3.741\,\text{kW} = 96.26\,\text{kW}$$

The rate at which the entropy of the high temperature reservoir changes, according to the definition of the entropy, is

$$\Delta\dot{S}_H = \frac{\dot{Q}_H}{T_H} = \frac{100\,\text{kW}}{294\,\text{K}} = \mathbf{0.340\ kW/K}$$

and that of the low-temperature reservoir is

$$\Delta\dot{S}_L = \frac{\dot{Q}_L}{T_L} = \frac{-96.26\,\text{kW}}{283\,\text{K}} = \mathbf{-0.340\ kW/K}$$

The net rate of entropy change of everything in this system is

$$\Delta\dot{S}_{\text{total}} = \Delta\dot{S}_H + \Delta\dot{S}_L = 0.340 - 0.340 = \mathbf{0\ kW/K}$$

as it must be since the heat pump is completely reversible.

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