

**6-80E** The sink temperature of a Carnot heat engine, the rate of heat rejection, and the thermal efficiency are given. The power output of the engine and the source temperature are to be determined.

**Assumptions** The Carnot heat engine operates steadily.

**Analysis** (a) The rate of heat input to this heat engine is determined from the definition of thermal efficiency,

$$\eta_{\text{th}} = 1 - \frac{\dot{Q}_L}{\dot{Q}_H} \longrightarrow 0.75 = 1 - \frac{800 \text{ Btu/min}}{\dot{Q}_H} \longrightarrow \dot{Q}_H = 3200 \text{ Btu/min}$$

Then the power output of this heat engine can be determined from

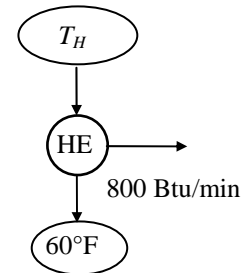
$$\dot{W}_{\text{net,out}} = \eta_{\text{th}} \dot{Q}_H = (0.75)(3200 \text{ Btu/min}) = 2400 \text{ Btu/min} = \mathbf{56.6 \text{ hp}}$$

(b) For reversible cyclic devices we have

$$\left( \frac{\dot{Q}_H}{\dot{Q}_L} \right)_{\text{rev}} = \left( \frac{T_H}{T_L} \right)$$

Thus the temperature of the source  $T_H$  must be

$$T_H = \left( \frac{\dot{Q}_H}{\dot{Q}_L} \right)_{\text{rev}} T_L = \left( \frac{3200 \text{ Btu/min}}{800 \text{ Btu/min}} \right) (520 \text{ R}) = \mathbf{2080 \text{ R}}$$



**6-81E** The claim of an inventor about the operation of a heat engine is to be evaluated.

**Assumptions** The heat engine operates steadily.

**Analysis** If this engine were completely reversible, the thermal efficiency would be

$$\eta_{\text{th,max}} = 1 - \frac{T_L}{T_H} = 1 - \frac{550 \text{ R}}{1000 \text{ R}} = 0.45$$

When the first law is applied to the engine above,

$$\dot{Q}_H = \dot{W}_{\text{net}} + \dot{Q}_L = (5 \text{ hp}) \left( \frac{2544.5 \text{ Btu/h}}{1 \text{ hp}} \right) + 15,000 \text{ Btu/h} = 27,720 \text{ Btu/h}$$

The actual thermal efficiency of the proposed heat engine is then

$$\eta_{\text{th}} = \frac{\dot{W}_{\text{net}}}{\dot{Q}_H} = \frac{5 \text{ hp}}{27,720 \text{ Btu/h}} \left( \frac{2544.5 \text{ Btu/h}}{1 \text{ hp}} \right) = 0.459$$

Since the thermal efficiency of the proposed heat engine is greater than that of a completely reversible heat engine which uses the same isothermal energy reservoirs, **the inventor's claim is invalid.**

