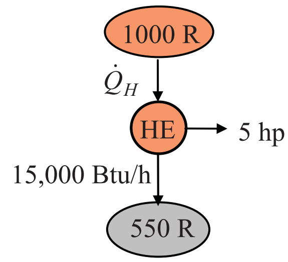
7-84E The claim of an inventor about the operation of a heat engine is to be evaluated.

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

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

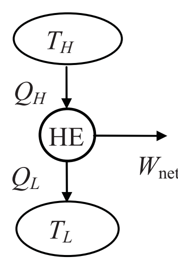
Since the thermal efficiency of the proposed heat engine is greater than that of a completely reversible heat engine which uses the same isothermal energy reservoirs, **the inventor's claim is invalid**.

7-85 The claim that the efficiency of a completely reversible heat engine can be doubled by doubling the temperature of the energy source is to be evaluated.

Assumptions The heat engine operates steadily.

Analysis The upper limit for the thermal efficiency of any heat engine occurs when a completely reversible engine operates between the same energy reservoirs. The thermal efficiency of this completely reversible engine is given by

$$\eta_{\text{th,rev}} = 1 - \frac{T_L}{T_H} = \frac{T_H - T_L}{T_H}$$



If we were to double the absolute temperature of the high temperature energy reservoir, the new thermal efficiency would be

$$\eta_{\text{th,rev}} = 1 - \frac{T_L}{2T_H} = \frac{2T_H - T_L}{2T_H} < 2\frac{T_H - T_L}{T_H}$$

The thermal efficiency is then **not doubled** as the temperature of the high temperature reservoir is doubled.