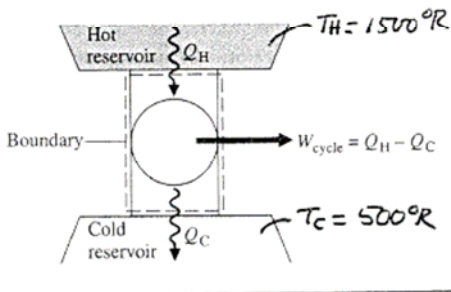


PROBLEM 5.18

KNOWN: Data are provided for a power cycle operating between hot and cold reservoirs.

FIND: In each case, determine whether the cycle operates reversibly, operates irreversibly, or is impossible.

SCHEMATIC & GIVEN DATA:



(a) $Q_H = 900 \text{ Btu}, W_{\text{cycle}} = 450 \text{ Btu}$

With the given data,

$$\eta = \frac{W_{\text{cycle}}}{Q_H} = \frac{450 \text{ Btu}}{900 \text{ Btu}} = 0.5$$

The maximum thermal efficiency is

$$\eta_{\text{MAX}} = 1 - \frac{T_C}{T_H} = 1 - \frac{500^\circ R}{1500^\circ R} = 0.667$$

Since $\eta < \eta_{\text{MAX}}$, the cycle operates irreversibly.

(b) $Q_H = 900 \text{ Btu}, Q_C = 300 \text{ Btu}$

From the energy balance

$$W_{\text{cycle}} = Q_H - Q_C = 900 - 300 = 600 \text{ Btu}$$

With those data, the thermal efficiency is

$$\eta = \frac{W_{\text{cycle}}}{Q_H} = \frac{600}{900} = 0.667$$

Since $\eta = \eta_{\text{MAX}}$, the cycle operates reversibly.
(Part (a))

(c) $W_{\text{cycle}} = 600 \text{ Btu}, Q_C = 400 \text{ Btu}$

From the energy balance

$$W_{\text{cycle}} = Q_H - Q_C$$

$$\Rightarrow Q_H = W_{\text{cycle}} + Q_C = 600 + 400 = 1000 \text{ Btu}$$

With those data, the thermal efficiency is

$$\eta = \frac{600}{1000} = 0.60$$

Since $\eta < \eta_{\text{MAX}}$, the cycle operates irreversibly.
(Part (a))

(d) $\eta = 70\%$

Since $\eta > \eta_{\text{MAX}} = 0.667$ (Part (a)), this cycle cannot operate as claimed. Impossible.