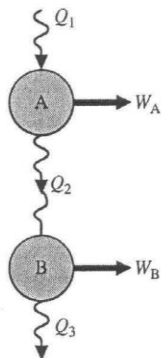


PROBLEM 2.86

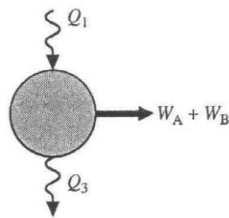
KNOWN: Power cycles A and B operate in series.

FIND: Determine an expression for the thermal efficiency of an overall cycle consisting of A and B together in terms of η_A and η_B .

SCHEMATIC & GIVEN DATA:



(a) A and B in series



(b) Overall cycle

ENGINEERING MODEL:

1. Cycles A, B and the overall cycle are power cycles.
2. Energy transfer is positive in the directions of the arrows on the schematic.

ANALYSIS:

$$\eta_A = \frac{W_A}{Q_1} = 1 - \frac{Q_2}{Q_1} \Rightarrow Q_2 = Q_1(1 - \eta_A) \quad (1)$$

$$\eta_B = \frac{W_B}{Q_2} = 1 - \frac{Q_3}{Q_2} \Rightarrow Q_3 = Q_2(1 - \eta_B) \quad (2)$$

$$= Q_1(1 - \eta_A)(1 - \eta_B) \quad (3)$$

$$\eta = \frac{(W_A + W_B)}{Q_1} = 1 - \frac{Q_3}{Q_1} \quad (4)$$

Introducing (3) into (4),

$$\eta = 1 - \frac{Q_1(1 - \eta_A)(1 - \eta_B)}{Q_1}$$

$$= 1 - (1 - \eta_A)(1 - \eta_B)$$

$$= 1 - (1 - \eta_A - \eta_B + \eta_A \eta_B)$$

$$\textcircled{1} \quad \therefore \eta = \eta_A + \eta_B - \eta_A \eta_B$$

1. Sample calculation: $\eta_A = 0.25$, $\eta_B = 0.32$

$$\begin{aligned} \eta &= 0.25 + 0.32 - (0.25)(0.32) \\ &= 0.49 \text{ (49\%)} \end{aligned}$$