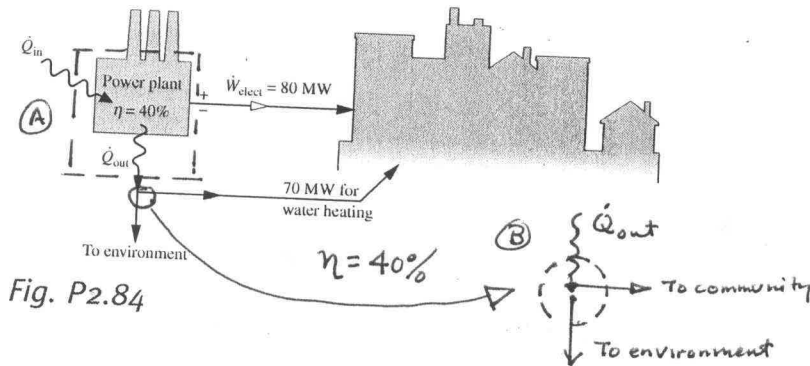


PROBLEM 2.84

KNOWN: Operating data are provided for a cogeneration power plant operating in a thermodynamic cycle at steady state.

FIND: Determine the rates at which energy is added by heat transfer and discarded to the environment. Also determine the value of the electricity generated.

SCHEMATIC & GIVEN DATA:



ENR. MODEL

1. As shown in the schematic, two systems — A and B — are considered.
2. Each system is at steady state. System A operates on a thermodynamic cycle.
3. Electricity is valued at \$0.08 per kW·h

ANALYSIS:

$$(a) \quad \eta = \frac{\dot{W}_{\text{elect}}}{\dot{Q}_{\text{in}}} \Rightarrow \dot{Q}_{\text{in}} = \frac{\dot{W}_{\text{elect}}}{\eta} = \frac{80 \text{ MW}}{0.40} = 200 \text{ MW}$$

← \dot{Q}_{in}

For the power plant, $\dot{W}_{\text{cycle}} = \dot{Q}_{\text{cycle}}$. That is

$$\dot{W}_{\text{elect}} = \dot{Q}_{\text{in}} - \dot{Q}_{\text{out}} \Rightarrow \dot{Q}_{\text{out}} = \dot{Q}_{\text{in}} - \dot{W}_{\text{elect}} = (200 - 80) \text{ MW} = 120 \text{ MW}$$

(b) Considering system B,

$$\dot{Q}_{\text{out}} = \dot{Q}_{\text{to environment}} + \dot{Q}_{\text{community}} \quad (\text{All terms are positive in the directions of the arrows.})$$

$$\Rightarrow \dot{Q}_{\text{to environment}} = \dot{Q}_{\text{out}} - \dot{Q}_{\text{community}} = 120 \text{ MW} - 70 \text{ MW} = 50 \text{ MW}$$

← To environment

$$(c) \quad \left[\text{Annual Value of Electricity} \right] = (80 \text{ MW}) \left| \frac{10^3 \text{ kW}}{1 \text{ MW}} \right| \left(365 \times 24 \frac{\text{h}}{\text{year}} \right) \left(\frac{\$0.08}{\text{kW}\cdot\text{h}} \right)$$

$$= \$56.1 \text{ M/year}$$

← Annual value