**PROBLEM 8.6**

**KNOWN:** Water is the working fluid in an ideal Rankine cycle. The condenser pressure and the turbine inlet state are specified. The mass flow of steam is given.

**FIND:** Determine (a) the net power, (b) the rate of heat transfer to the steam passing through the boiler, (c) the thermal efficiency, and (d) the mass flow rate of cooling water passing through the condenser.

**SCHEMATIC & GIVEN DATA:**

[Diagram with symbols and values]

**ENGINEERING MODEL:** See Example 8.1.

**ANALYSIS:** First, fix each of the principal states.

- **State 1:** $p_1 = 160$ bar, sat. vapor $\Rightarrow h_1 = 2580.6$ kJ/kg, $s_1 = 5.2488$ kJ/kg K
- **State 2:** $p_2 = 0.08$ bar, $s_2 = s_1 \Rightarrow x_2 = \frac{s_2 - S_{f2}}{S_{g2} - S_{f2}} = 0.6091$, $h_2 = 1637.6$ kJ/kg
- **State 3:** $p_3 = 0.08$ bar, sat. liquid $\Rightarrow h_3 = 173.88$ kJ/kg
- **State 4:** $p_4 = 160$ bar, $h_4 = h_3 + \nu_3(p_4 - p_3)$

(a) The net power developed is

$\dot{W}_{cycle} = \dot{W}_e - \dot{W}_p = \dot{m}(h_1 - h_2) - (h_4 - h_3)$

$= 120 \frac{\text{kW}}{\text{kg}} \left[ (2580.6 - 1637.6) - (190.01 - 173.88) \right] \frac{\text{kJ}}{\text{kg}} \left( \frac{1 \text{ kW}}{1 \text{ kJ/kg}} \right) = 1.112 \times 10^5 \text{ kW}$

(b) For the steam passing through the boiler

$\dot{q}_{in} = \dot{m}(h_1 - h_4) = (120)(2580.6 - 190.01) = 2.869 \times 10^5$ kW

(c) $\eta = \frac{\dot{W}_{cycle}}{\dot{q}_{in}} = 0.388 (38.8\%)$

(d) For the control volume enclosing the condenser (assuming $\Delta h_{cw} = \dot{c}_w \Delta T_{cw}$)

$\dot{m}_{cw} = \frac{\dot{m}(h_2 - h_5)}{c_w \Delta T_{cw}}$

With $c_w = 4.179$ kJ/kg K from Table A-19

$\dot{m}_{cw} = \frac{(120)(1637.6 - 173.88)}{(4.179)(18)} = 2335 \frac{\text{kg}}{\text{s}}$

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