PBC5

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Heat exchanger

T_{out} = exit temp. of exhaust
T_{in} = inlet temp of exhaust

$(q_{in})_{Boiler} = (q_{out})_{Heat\ Exchanger}$

$\downarrow$

$-q_{in} = c_p(T_{out} - T_{in})$

$h_2 - h_3 = c_p(T_{out} - T_{in})$

$h_3 = h_2 + c_p(T_{in} - T_{out})$

$h_3 = h_2 + q_{in}$

$T_{in} = 602.66\ ^\circ C$

$T_{out} = 90\ ^\circ C$

$c_p = 5.25\ kJ/kg \cdot K$

$q_{in} = 5.25(602.66 - 90)$

a) $q_{in} = 2691.465\ kJ/kg$

Rankine cycle

$T_1 = T_4 = 25\ ^\circ C$

$P_1 = P_{sat@25^\circ C} = 3.1698\ kPa$

$P_2 = 2\ MPa$

$h_1 = h_{f@25^\circ C} = 104.83\ kJ/kg$

$\underline{v}_1 = \underline{v}_{f@25^\circ C} = 0.001003\ m^3/kg$

$(w_{pump})_{in} = \underline{v}_1(P_2 - P_1)$

$= 0.001003(2000 - 3.1698)$

$$= 0.001003(2000 - 3.1698)$$

$$= 2.003$$

$$h_2 = h_1 + (w_{pump})_{in}$$

$$= 106.833 \text{ kJ/kg}$$

$$h_3 = h_2 + q_{in} \quad \text{(from heat exchanger)}$$

$$h_3 = 106.833 + 2691.465$$

$$h_3 = 2798.3 \text{ kJ/kg}$$

$$\left.\begin{array}{l} h_3 = 2798.3 \\ P_3 = P_2 = 2 MPa \end{array}\right\} \Rightarrow s_3 = s_{g@2MPa} = 6.3390 \text{ kJ/kg·K}$$

$$\left.\begin{array}{l} s_4 = s_3 = 6.339 \\ T_4 = 25°C \end{array}\right\} \Rightarrow x_4 = \frac{s - s_f}{s_{fg}} = \frac{6.339 - 0.3672}{8.1895}$$

$$x_4 = 0.729$$

$$h_4 = h_{f@25°C} + x\, h_{fg@25°C}$$

$$h_4 = 104.83 + (0.729)2441.7$$

$$h_4 = 1884.83 \text{ kJ/kg}$$

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b) $(W_{Turbine})_{out} = h_3 - h_4$

$= 913.47 \text{ kJ/kg}$

c) $\eta_{th} = 1 - \frac{q_{out}}{q_{in}}$

$= 1 - \frac{h_4 - h_1}{q_{in}}$

$= 1 - \frac{1884.83 - 104.83}{2691.465}$

$= 0.33865$

$\doteq 33.9\%$