Class: 4th Stage
Subject: Computer Applications 4
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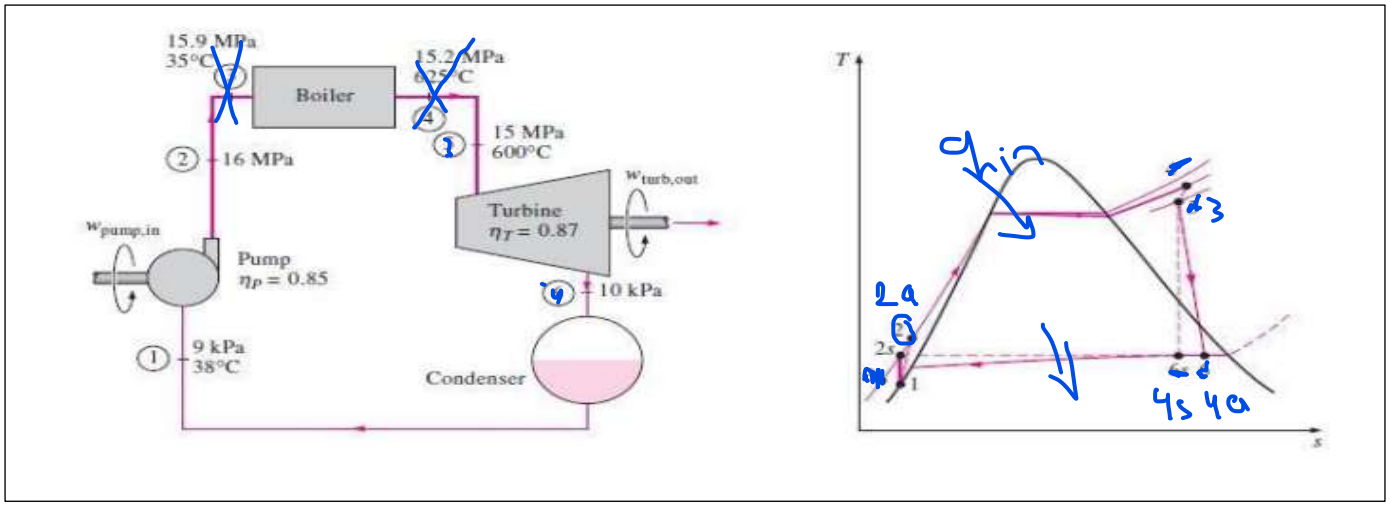
Lecture Two

Example (5.2): A steam power plant operates on the cycle shown in the figure below. If the isentropic efficiency of the turbine is 87% and the isentropic efficiency of the pump is 85%, determine: (a) the thermal efficiency of the cycle (b) the net power output of the plant for a mass flow rate of 15 kg/s.



Sol) $P_1 = 9\ kPa \longrightarrow$ table A-5

$h_f = 180.28\ kJ/kg = h_1$

$v_f = v_1 = 0.001009\ m^3/kg$, $P_3 = 15\ MPa$, $T_3 = 600\ °C$

$\longrightarrow$ table A-6 $\Longrightarrow h_3 = 3583.1\ kJ/kg$

$S_3 = 6.6796\ kJ/kg.K$, $P_4 = 10\ kPa \longrightarrow$ table $\longrightarrow$ A-5, $h_g = 191.81\ kJ/kg$

$h_{fg} = 2392.1\ kJ/kg$, $S_f = 0.6492\ kJ/kg.K$, $S_{fg} = 7.4996\ kJ/kg.K$

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$W_{ps} = h_{2s} - h_1 = v_1(P_2 - P_1) \Rightarrow h_{2s} = v_1(P_2 - P_1) + h_1$

$h_{2s} = 0.001009(16000 - 9) + 180.28 \Rightarrow h_{2s} = 196.4 \text{ KJ/kg}$

$\eta_p = \frac{h_{2s} - h_1}{h_{2a} - h_1} \Rightarrow h_{2a} - h_1 = \frac{196.4 - 180.28}{0.85} \Rightarrow h_{2a} = 18.96 + 180.28$

$\Rightarrow h_{2a} = 199.26 \text{ KJ/kg}$

$s_3 = s_{4s}, x_4 = \frac{s_{4s} - s_f}{s_{fg}} \Rightarrow x_4 = \frac{6.6796 - 0.6492}{7.4996}$

$x_4 = 0.804$

$h_{4s} = h_f + x_4 h_{fg} \Longrightarrow h_{4s} = 191.81 + 0.804(2392.1)$

$h_{4s} = 2115.29 \text{ KJ/kg}$

$\eta_T = \frac{h_3 - h_{4a}}{h_3 - h_{4s}} \Rightarrow h_3 - h_{4a} = 0.87(3583.1 - 2115.29)$

$h_{4a} = 3583.1 - 1277$

$h_{4a} = 2306.1 \text{ KJ/kg}$

$q_{in} = h_3 - h_{2a} \Rightarrow q_{in} = 3583.1 - 199.26 = 3383.84 \text{ KJ/kg}$

$q_{out} = h_{4a} - h_1 \Rightarrow h_{out} = 2306.1 - 180.1 = 2126 \text{ KJ/kg}$

$W_{net} = q_{in} - q_{out} \Rightarrow W_{net} = 1257.84 \text{ KJ/kg}$

$\eta_{th} = \frac{W_{net}}{q_{in}} \Rightarrow \eta_{th} = \frac{1257.84}{3383.84}$

$\eta_{th} = 0.37 \times 100\%$

$\eta_{th} = 37.17$

$Power = \dot{m} \times W_{net} \Rightarrow Power = 15 \times 1257.84$

$Power = 18867 W = 18.86 \text{ KW}$