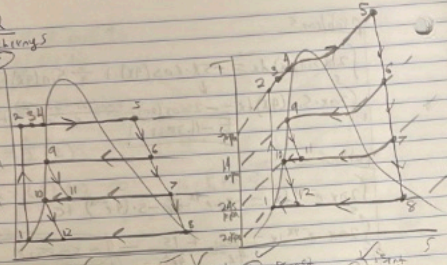
HW 2.2

Nathan Cherng 5

10-57



$y = 0.1446$

$\dot{m}_F = 75\ kg/s$

$Z = 0.0981$

$c_p = 1.18$

① Pump → ② Preconst Turbine → ③ Preconst Turbine → ④ Preconst Boiler → ⑤ Const Turbine

$p_1 = 20kPa$ $h_1 = 251.42\frac{kJ}{kg}$ | $p_2 = 5MPa$ $h_2 = 256.48\frac{kJ}{kg}$ | $p_3 = p_2$ $h_3 = 583\frac{kJ}{kg}$ | $p_4 = p_2$ $h_4 = 829.96\frac{kJ}{kg}$ | $p_5 = p_2$ $T_5 = 700°C$ $h_5 = 3900.3\frac{kJ}{kg}$

⑤ Isot Turbine → ⑦ Isot Turbine → ⑧ Preconst Condenser → ⑫ Preconst Condenser → ①

$p_6 = 1.4MPa$ $h_6 = 3406\frac{kJ}{kg}$ | $p_7 = 245kPa$ $h_7 = 2981\frac{kJ}{kg}$ | $p_8 = 20kPa$ $h_8 = 2477\frac{kJ}{kg}$ | $p_{12} = p_1$ $h_{12} = 533\frac{kJ}{kg}$

⑨ Pump → ⑩ Preconst → ⑪ Const Boiler

$p_9 = 1.4MPa$ $h_9 = 829.96\frac{kJ}{kg}$ | $p_{10} = 245kPa$ $h_{10} = 838.98\frac{kJ}{kg}$ | $p_{11} = p_{10}$ $h_{11} = 533\frac{kJ}{kg}$

States:

① ⑫

$h_2 - h_1 = v_1(p_2 - p_1)$ $h_1 = 251.42\frac{kJ}{kg}$ $v_1 = 0.001017\ m^3/kg$

$h_2 = 251.42 + 5.065 = 256.48\frac{kJ}{kg}$

⑤ → ⑥ → ⑦ → ⑧ $s_5 = 7.5136\frac{kJ}{kg \cdot K}$

$s_5 = s_6 = s_7 = s_8$

⑧ sat liquid @ p_{12} ⇒ interpolate ⇒ $h_{11} = 533\frac{kJ}{kg}$ $h_{11} = h_{12}$

④ sat liquid @ p_4 ⇒ $h_4 = 829.96\frac{kJ}{kg}$ $h_9 = h_{10}$

$z = 0.0981$

1st law ③ $h_3 - h_m = z(h_7) + y(h_{10}) - (z+y)(h_{11})$ → $h_3 = (82.75 - 29.35)$

$h_3 = 533\frac{kJ}{kg}$

1st law ④ $h_4 - h_3 = y(h_9 - h_8)$ $h_4 = 829.96\frac{kJ}{kg}$

1st law $y(h_{10}) + z(h_2) + h_2 = (y+z)h_{11} + h_4$

$\dot{M}_{water} = \frac{\dot{m}_5(1-y-z)h_5 + (y+z)h_{12} - h_1)}{c_p \cdot \Delta T} = \frac{75(1875.93 + 129 - 251.42}{4K \cdot 1.0}$

$\dot{M}_w = 3146.7\frac{kg}{s}$

⑤ $W_{out} = h_5 - yh_6 - zh_7 - (1-z-y)h_8 = 3900.3 - 492.5 - 285.25 - 1875.83$

$W_{out} = 1245.712\frac{kJ}{kg}$

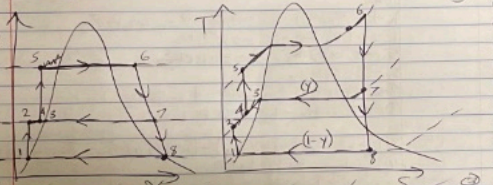
$W_{net} = W_{out} + W_{in} = 1245.712 - 5.065 = 1240.6469$

$\eta_t = \frac{W_{net}}{q_{in}}$

$q_{in} = h_5 - h_4 = 3900.3\frac{kJ}{kg} - 829.96\frac{kJ}{kg} = 3070.34\frac{kJ}{kg}$

$\eta_t = \frac{1240.6469\frac{kJ}{kg}}{3070.34\frac{kJ}{kg}} = 0.404 = \eta_t$

10-69



y = 0.25

① pump ② ④ pump ⑤ ⑥ isent ⑦ ③

$P_1 = 10kPa$ $P_2 = 1.2MPa$ $P_4 = 1.2MPa$ $P_5 = 4MPa$ $P_6 = 1.2MPa$ $P_7 = 1.2MPa$

$h_1 = 191.81 \frac{kJ}{kg}$ $h_2 = 4504 \frac{kJ}{kg}$ $h_4 = 3496.8 \frac{kJ}{kg}$ ~~$T_5 = 300°C$~~ $h_7 = 3079.7 \frac{kJ}{kg}$

$V_1 = 0.001 \frac{m^3}{kg}$ ~~$P_5 = 4MPa$~~ $h_5 = 3446.0 \frac{kJ}{kg}$

$h_6 = 550.11 \frac{kJ}{kg}$

⑦ isent ⑧ ⑦ sat. liquid ③ ④

$P_8 = 10kPa$ $P_3 = 1.2MPa$

$h_8 = 2246.0 \frac{kJ}{kg}$ $h_3 = 798.33 \frac{kJ}{kg}$

$h_1 =$ Sat. Liquid Water@ $P_1 = 191.81 \frac{kJ}{kg}$

$V_1 = 0.001 \frac{m^3}{kg}$

~~$h_7 = 3079.7 \frac{kJ}{kg}$ $T_7 = 300°C$~~

$S_6 = S_7 = S_8$ $S_6 = 7.0922 \frac{kJ}{kg \cdot K}$

h_6 @ superheated $= 3079.7 \frac{kJ}{kg}$

h_6 @ interpolated $= 2246.0 \frac{kJ}{kg}$

$h_2 - h_1 = v_1(P_2 - P_1)$

$h_2 = 191.81 \frac{kJ}{kg} + 0.001 \frac{m^3}{kg}(1200kPa - 10kPa)$

$h_2 = 193.01 \frac{kJ}{kg}$

1st law → ~~mass~~ $y(h_3) + (1-y)(h_2) - h_4 = 0$

$0.25(798.33 \frac{kJ}{kg}) + 0.75(193.01 \frac{kJ}{kg}) = h_4$

$h_4 = 344.32 \frac{kJ}{kg}$

1st law mixing chamber

$h_5 - h_4 = v_4(P_5 - P_4)$

$h_5 = 344.32 \frac{kJ}{kg} + 0.001 \frac{m^3}{kg}(7MPa - 1.2MPa)$

$h_5 = 350.14 \frac{kJ}{kg}$

D

Work produced

1st law $W_{out} = W_{turbine}$ $\dot{m} = 55 \frac{kg}{s}$

$-W_{in} = (h_7 - h_6) + (h_8 - h_8)$

$-W_{out} = (0.25)(55 \frac{kg}{s})(h_7 - h_6) + (0.75)(55 \frac{kg}{s})(h_8 - h_6)$

$-W_{out} = (13.75)(3079.7 \frac{kJ}{kg} - 346 \frac{kJ}{kg}) + (41.25)(2246 \frac{kJ}{kg} - 346 \frac{kJ}{kg})$

$= 50362.25 + 99500 kW$

$W_{out} = 54,536.625 KW$

$U = \frac{W_{out} + Q_P}{Q_{in}}$

$W_{in} = (\dot{m})(1-y)(h_6 - h_5) + (\dot{m})(h_5 - h_4)$

$W_{in} = 49.5 + 3M$

$W_{in} = 368.5$

$W_{out} - W_{in} = 54,536.625 KW - 368.5 KW$

$W_{out} = 54168.125 KW$

D $Q_{in} = \dot{m}(h_6 - h_5) = 55 \frac{kg}{s}(3496 \frac{kJ}{kg} - 350.14 \frac{kJ}{kg})$

$Q_{in} = 172272.3 KW$

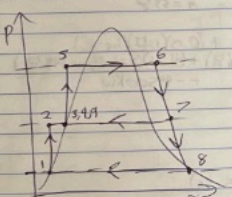
heat processing $Q_P = \dot{m} \cdot y(h_7 - h_3) = (55 \cdot 0.25)(3079.7 \frac{kJ}{kg} - 798.33 \frac{kJ}{kg})$

$Q_P = 31368.8375 KW$

$U = \frac{54168.125 KW + 31368.8375 KW}{172272.3 KW}$

$U = 0.502$

10-72



① pump ② → ③ → ④ pump ⑤ → ⑥ → ⑦ → ⑧ → ①

isent isent

$P_1 = 8kPa$ $P_2 = 16MPa$ $P_3 = 16MPa$ $P_4 = 16MPa$ $P_5 = 14MPa$ $P_6 = 14MPa$ $P_7 = 10kPa$

$h_1 = 173.88 \frac{kJ}{kg}$ $h_2 = 205.88 \frac{kJ}{kg}$ $h_3 = 857.99 \frac{kJ}{kg}$ $h_4 = 857.99 \frac{kJ}{kg}$ $T_5 = 600°C$ $h_5 = 3583 \frac{kJ}{kg}$ $T_6 = 40°C$ $h_6 = 2729.452 \frac{kJ}{kg}$

$\dot{m} = 100 \frac{kg}{s}$ $v_1 = 0.001008 \frac{m^3}{kg}$ $v_4 = 0.001558 \frac{m^3}{kg}$ $s_5 = 6.6582 \frac{kJ}{kg \cdot K}$ $h_7 = 2118.8 \frac{kJ}{kg}$ $h_8 = 2176.619 \frac{kJ}{kg}$

⑨ → ④

$P_9 = 16MPa$

$h_9 = 857.99 \frac{kJ}{kg}$

Sat liquid → h@ P_1 $= 191.81 \frac{kJ}{kg}$ $h_2 - h_1 = v_1(P_2 - P_1)$ $s_6 = s_7 = s_8$

v@ $P_1 = 0.001010 \frac{m^3}{kg}$ $h_2 = 193.42 \frac{kJ}{kg}$ set interpolate h_7 & h_8

h_3 → interpolate at Sat liquid → $h_3 = 857.99 \frac{kJ}{kg}$ $h_7 = h_f + X_7 h_{fg}$

$h_3 = h_4 =$ isenthalpic h $X_7 = \frac{s_7 - s_f}{s_{fg}}$ → interpolate

$X_8 = \frac{s_8 - s_f}{s_{fg}}$ h_f → table $= 857.99 \frac{kJ}{kg}$ $X_7 = \frac{6.582 \frac{kJ}{kg \cdot K} - 2.3423 \frac{kJ}{kg \cdot K}}{4.0959 \frac{kJ}{kg \cdot K}}$

$X_8 = \frac{6.582 \frac{kJ}{kg \cdot K} - 0.6992 \frac{kJ}{kg \cdot K}}{7.4996 \frac{kJ}{kg \cdot K}}$ h_{fg} → table $= 1934.68 \frac{kJ}{kg}$ $X_7 = 0.967$

$X_8 = 0.8297$ $h_7 = 857.99 \frac{kJ}{kg} + 0.967(1934.68)$

$h_8 = h_{f8} + X_8(h_{fg8})$ $h_7 = 2729.452 \frac{kJ}{kg}$

$h_8 = 2176.619 \frac{kJ}{kg}$

$h_5 - h_4 = v_4(P_5 - P_4)$

$v_4 = 0.001558 \frac{m^3}{kg}$

$h_5 = 857.99 \frac{kJ}{kg} + 0.001558 \frac{m^3}{kg}(14MPa - 16MPa)$ (kPa! cancel)

$h_5 = 866.565$

$\dot{W}_{net} = 25MW$

$w_{NET} = w_{out} - w_{in}$

$\gamma = 0.35$ $w_{out} = (h_6 - h_7) + (1-\gamma)(h_8 - h_7)$

$1-\gamma = 0.65$ $= (2118.8 \frac{kJ}{kg} - 2729.452 \frac{kJ}{kg}) + (0.65)(2729.452 \frac{kJ}{kg} - 2176.619 \frac{kJ}{kg})$

$389.348 + 359.341 \frac{kJ}{kg}$

$w_{out} = 748.69 \frac{kJ}{kg}$

$w_{in} = (1-\gamma)(h_2 - h_1) + (h_5 - h_4)$

$= (0.65)(1.61 \frac{kJ}{kg}) + (8.57 \frac{kJ}{kg})$

$w_{in} = 9.6215 \frac{kJ}{kg}$

$w_{NET} = 748.69 - 9.6215 = 739.0685 \frac{kJ}{kg}$

$\frac{\dot{W}}{\dot{m}} = \dot{m} = \frac{25000 kW}{739.0685 \frac{kJ}{kg}} = \boxed{33.826 \frac{kg}{s}}$