1

Josh Whitehead
U1069343

Thermo HW 6

1.) $\dot{W}_{s,net} = 300\ MW$ $\quad \dot{m} = 115000 \frac{kg}{hr}$ $\quad HHV = 29000 \frac{kJ}{kg}$

$\dot{m} = 31.94 \frac{kg}{sec}$

$$\eta_{overall} = \frac{\dot{W}_{s,net}}{HHV \cdot \dot{m}_{coal}} = \frac{300000\ kW}{29000 \frac{kJ}{kg} \cdot 31.94 \frac{kg}{sec}} = 0.324 \boxed{= 32.4\%}$$

2.) $\dot{W}_{s,net} = 600\ MW$ $\quad \eta_{\theta} = 0.40$ $\quad \eta_{gen} = 0.100$

$\underline{Q_H - Q_C = W_{s,net}}$, $\quad \eta_{\theta} = \frac{W_{s,net}}{Q_H} \rightarrow Q_H = \frac{W_{s,net}}{\eta_{\theta}}$

$\therefore Q_C = W_{s,net} + Q_H \rightarrow \underline{Q_C = \frac{W_{s,net}}{\eta_{\theta}} - W_{s,net}}$

$$Q_C = \frac{600000\ kW}{0.40} - 600000\ kW = 900000\ kW \boxed{= 900\ MW}$$

Actual Q_C would be lower because $\eta_{gen,actual} < 0.100$

and $\eta_{\theta}\eta_{boil}\eta_{gen} = \frac{\dot{W}_{s,net}}{HHV \cdot \dot{m}}$ $\therefore$ (assuming HHV and $\dot{m}$ remain ~~unchanged~~ unchanged) if η_{gen} decreases, $\dot{W}_{s,net}$ would have to decrease also.

HW6

3. $W_{s,net} = 100\ kW \qquad Q_H = 400\ kW$

$$\eta_\theta = 1 - \frac{Q_C}{Q_H} \qquad Q_H - Q_C - W_{s,net} = 0$$

$$\therefore \eta_\theta = 1 - \frac{Q_H - W_{s,net}}{Q_H} = 1 - \frac{(400-100)\cancel{kW}}{400\ \cancel{kW}} = 1 - \frac{3}{4} = \frac{1}{4} = 0.25 = \boxed{25\%}$$

4. $$\eta_\theta = 1 - \frac{Q_C}{Q_H} \rightarrow \frac{Q_C}{Q_H} = \frac{T_C}{T_H}$$

$T_C = 25°C = \underline{298.15\ K}$

$T_H = 450°C = \underline{723.15\ K}$

$$\eta_{\theta\,max} = 1 - \frac{298.15\ \cancel{K}}{723.15\ \cancel{K}} = 1 - 0.412 \boxed{= 0.588}$$

The actual efficiency might be less than the estimated due to heat lost to the surroundings.

HW 6

5) $T_H = 85°C$ $P = 101.3\ kPa$ $x_E = 0.45$ $C_{\cancel{E}} = 4.2 \frac{kJ}{kg\,K}$

$T_C = 20°C$ $x_w = 0.55$ $C_{\cancel{E}} = 2.84 \frac{kJ}{kg\,K}$

$\Delta H_w^{vap} = 2300 \frac{kJ}{kg\,\cancel{K}}$ $M_E = 46 \frac{kg}{kmol}$

$\Delta H_E^{vap} = 844 \frac{kJ}{kg\,\cancel{K}}$ $M_w = 18 \frac{kg}{kmol}$

$$H^{is} = \sum_i x_i H_i$$

$$H_{1E} = 0 + \Delta H_E + \Delta H_E^{vap} = 0 + C_E(\Delta T)\frac{kJ}{kg} + 844\frac{kJ}{kg} = 0 + 2.84(65) + 844$$

$$H_{1E} = 1028.6 \frac{kJ}{kg} \cdot 46 \frac{kg}{kmol} = \underbrace{47 \times 10^3 \frac{kJ}{kmol}}$$

$$H_{1w} = 0 + \Delta H_w + \Delta H_w^{vap} = 0 + C_w(\Delta T) + 2300 = 4.2(65) + 2300$$

$$H_{1w} = 2612 \frac{kJ}{kg} \cdot 18 \frac{kg}{kmol} = 47 \times 10^3 \frac{kJ}{kmol}$$

$$H = x_E(H_{1E}) + x_w(H_{1w}) = 0.45(47 \times 10^3) + 0.55(47 \cdot 10^3)$$

$H_1^{is} = 4.7 \times 10^4$

$H_2^{is} = 0$

$$Q = H_2 - H_1 = 0 - 4.7 \times 10^4 = \boxed{4.7 \times 10^4 \frac{kJ}{kmol}}$$