نموذج اجابة لمقرر محطات حرارية (١)

الفرقة الثالثة ميكانيكا قوى

٢٠١٧ - ٢٠١٨

ترم أول

د/ ماجده قطب العزازي

Q1 [15]

1) ✓

2) X increases

3) X 0 %

4) X 165 bar

5) X non identical

6) X Feed water or IM super heater

7) X simple gas Turbines cycle or without or not suit

8) X decreases

9) ✓

10) X stay constant or velocity decreases

11) ✓

12) X in condenser

Q2 [15 Marks]

Given:- $P_1 = 28$ bar $T_1 = 400°C$ $P_c = 0.03332$ bar

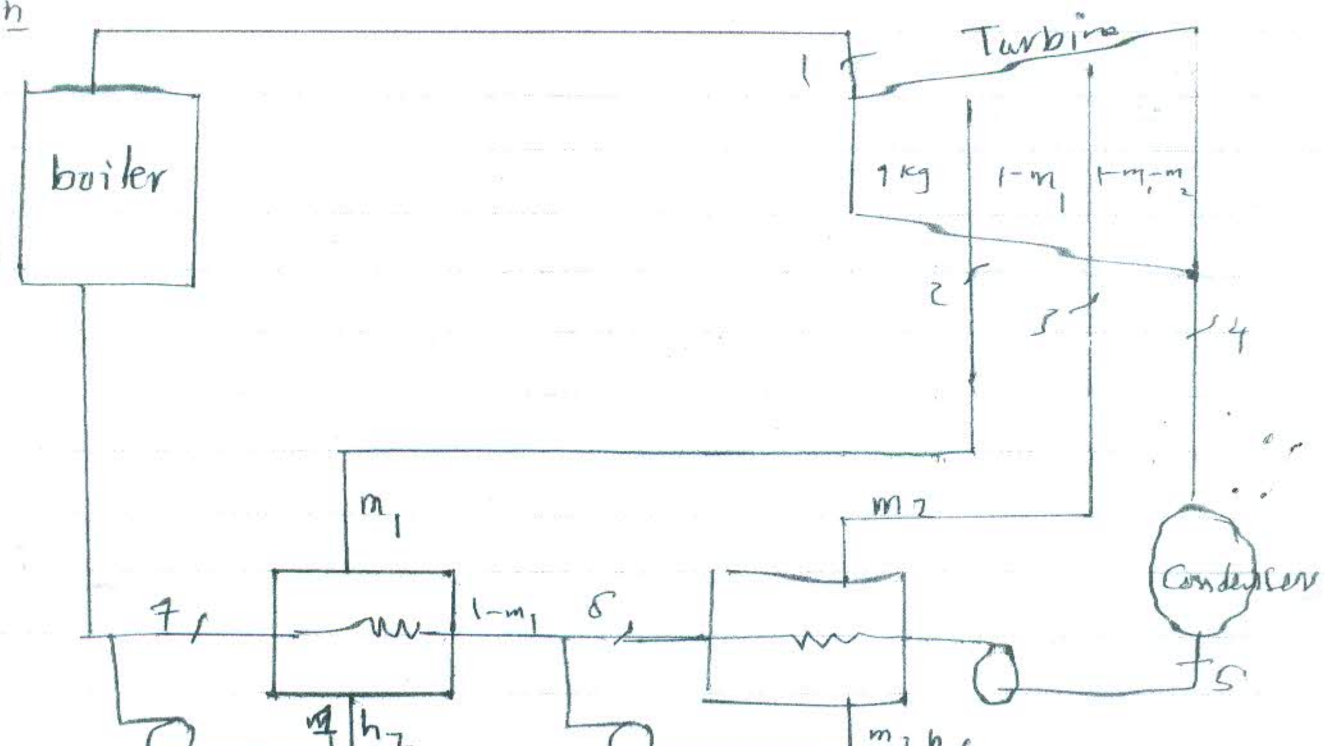
$x_4 = 90\%$ $h_1 - h_2 = h_2 - h_3 = h_3 - h_4$

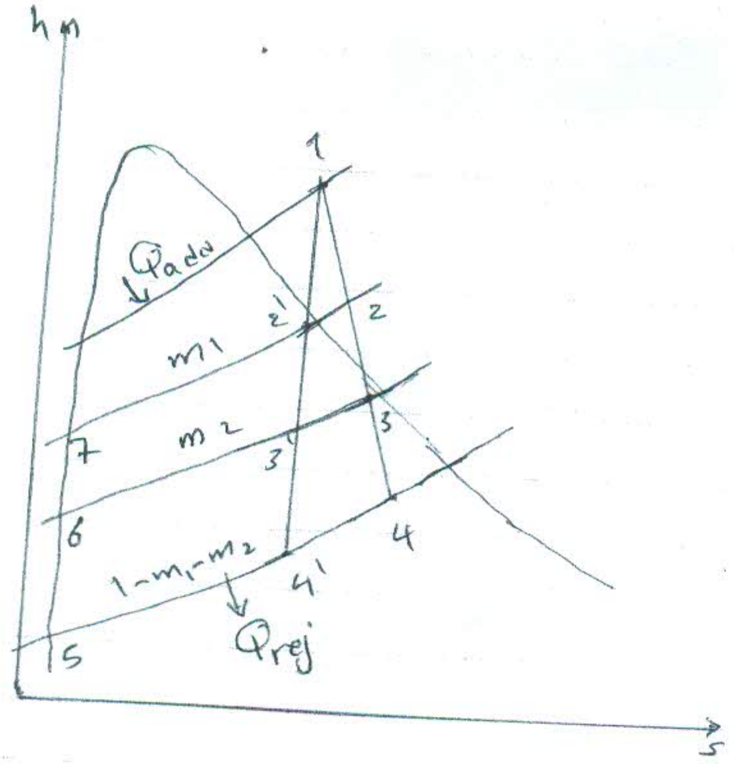
Req:- a) The bleeding pressures

b) η_{Th}

c) η_t

Soln




h
1
Qadd
m1
2'
2
7
m2
3
3'
6
4
1-m1-m2
4'
Qrej
5
s

at $P_1 = 28$ bar $\quad T_1 = 400^\circ C \quad h_1 = 3235$ kJ/kg

at $P_4 = P_c = 0.0332$ bar $\quad x_4 = 0.9 \quad h_4 = 2310$ kJ/kg

$$\frac{h_1 - h_4}{3} = \frac{3235 - 2310}{3} = 308.4 \text{ kJ/kg}$$

$h_1 - h_2 = 308.4 \qquad h_2 = 2926.6$ kJ/kg

$h_2 - h_3 = 308.4 \qquad h_3 = 2618.2$ kJ/kg

P_2 at $h_2 = 2926.6 \qquad P_2 = 5$ bar

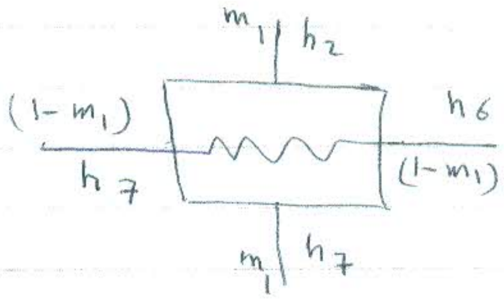
P_3 at $h_3 = 2618.2 \qquad P_3 = 0.55$ bar

$P_5 = 0.03332$ bar at sat $\qquad h_5 = \frac{121.4 + 73.5}{2} \approx 100$ kJ/kg

$P_6 = 0.55$ bar at sat $\qquad h_6 = 350.6$ kJ/kg

$P_7 = 5$ bar at sat $\qquad h_7 = 640.1$ kJ/kg

Heat balance of feed water heater (I)

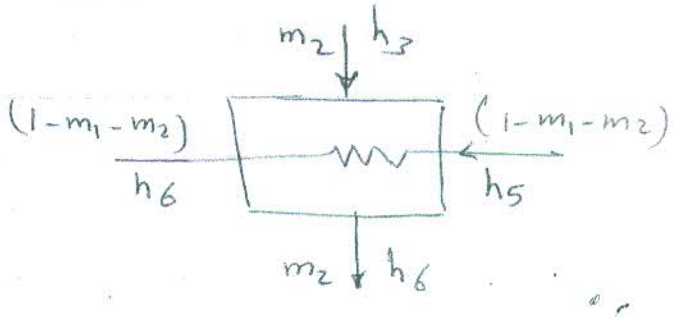


$m_1 h_2 + (1 - m_1) h_6$

$= m_1 h_7 + (1 - m_1) h_7$

$$m_1 = \frac{h_7 - h_6}{(h_2 - h_7) + (h_7 - h_6)} = \frac{640.1 - 350.6}{2926.6 - 350.6} = 0.1124 \ \frac{kg_{st}}{kg_{st}}$$

Heat balance of feedwater heater (II)



$$m_2 h_3 + (1 - m_1 - m_2) h_5$$

$$= m_2 h_6 + (1 - m_1 - m_2) h_6$$

$$m_2 = \frac{(1 - m_1) h_6 - (1 - m_1) h_6}{h_3 - h_5}$$

$$= \frac{(1 - 0.1124)(350.6 - 100)}{2018.2 - 100} = 0.0883 \ kg_{sat} / kg_{st}$$

$$\eta_{th} = \frac{(h_1 - h_2) + (1 - m_1)(h_2 - h_3) + (1 - m_1 - m_2)(h_3 - h_4)}{h_1 - h_7}$$

$$= \frac{308.4 \left[1 + 1 - 0.1124 + 1 - 0.1124 - 0.0883\right]}{3235 - 646.1} = 32\%$$

$$\eta_t = \frac{h_1 - h_4}{h_1 - h_{4s}} = \frac{3235 - 2310}{3235 - 2075} = 80\%$$

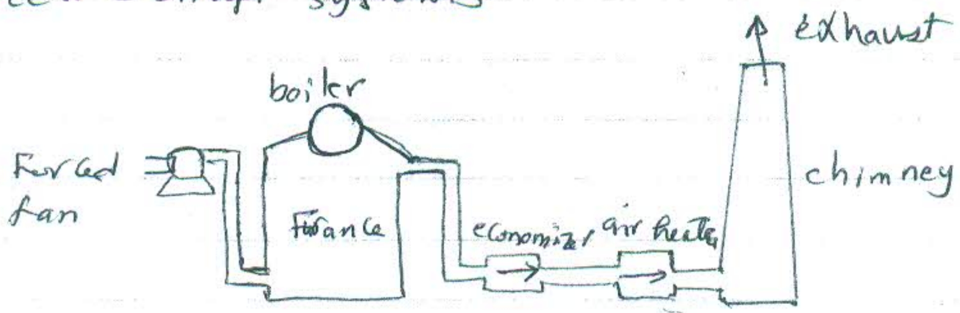
h_{4s} at $s_1 = s_{4s}$ $\quad h_{4s} = 2075$ kJ / kg

(Q_3 [a] [25 marks]

Large steam generators require an assist to push the air in; pull the gas out, or both. The basic types of mechanical systems are

a) Forced draft b) induced draft c) balanced draft

a) Forced - draft systems



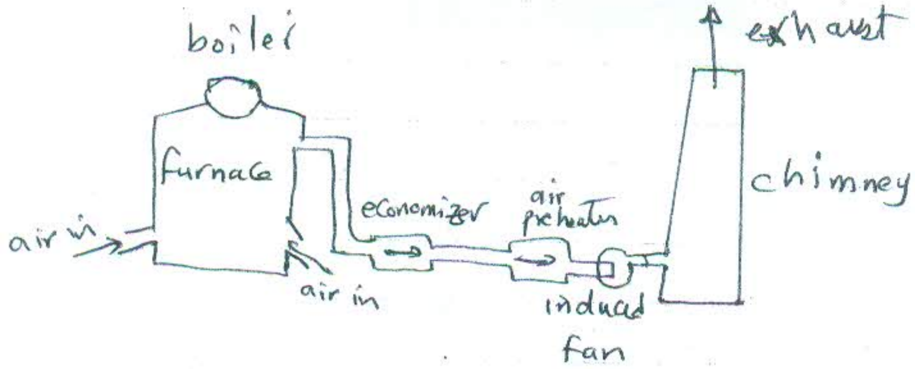
in the forced draft system, the fan placed at the air enterance to the air preheater. the forced fan pumps only cold, clean combustion air, and the resulting positive pressure in the combustion chamber improves the gas side convection coefficient.

$$\dot{m}_{f.d} = \dot{m}_F \left(\frac{A}{F}\right) \quad \text{or}$$

$$\dot{m}_{f.d} = \dot{m}_f (1+w)(A/F)$$

There are two types of fans in common use centerifugal and axial.

b) induced-draft systems

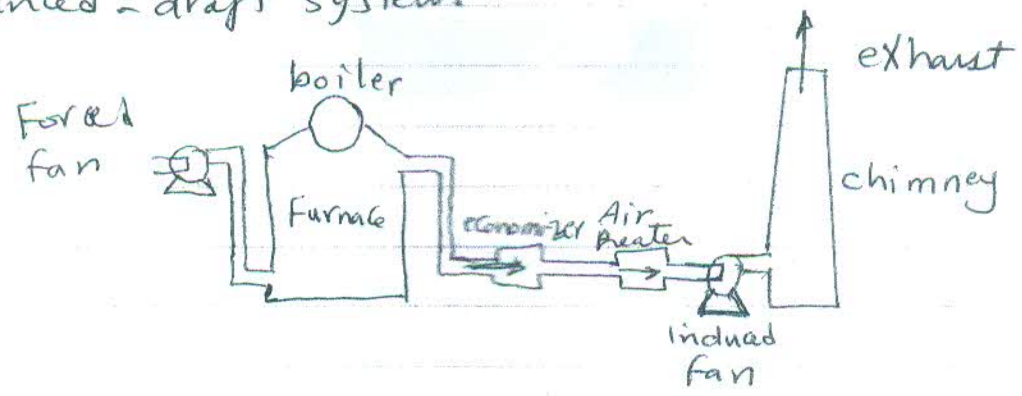


in induced-draft system the fan is located in the gas stream between the air preheater and the stack. It draws combustion products from the combustion chamber and discharges them into the stack. This produces a negative pressure in the combustion chamber, eliminating the leakage problem.

$$\dot{m}_{i\text{-}d} = \dot{m}_f \left[(A/F) + 1 - R \right] \quad \text{or}$$

$$\dot{m}_{i\text{-}d} = \dot{m}_f \left[(A/F)(1+w) + 1 - R \right]$$

(c) balanced - draft system



balanced - draft system employs both forced draft and induced draft fan. in this system, the combustion chamber operates at or slightly below atmospheric pressure. The forced fan push air through the air preheater, dampers, various air ducts, and burners into furnace. The induced fan pull the combustion gases from the furnace to stack.

* The advantages of forced draft over the induced draft are

1- They have lower maintenance problems.

2- They consume much less power.

3- Their capital and operating costs are lower.

4- Their Load is reduced by the absence of fued added

(Q3 [b]

$$\eta_{th_p} = \frac{Power}{\dot{m}_f \cdot HV} = \frac{300 * 10^3}{\dot{m}_f * 44000} = 0.35$$

$$\dot{m}_f = \frac{300 * 10^3}{(1-0.14-0.11) * 0.35 * 44000} = \frac{300 * 10^3}{11550} = 25.974$$

$$\eta_{th_c} = \frac{Power}{Q_{add}} \Longrightarrow Q_{add} = \frac{300 * 10^3}{0.43} = 697674.418$$

$$Q_f = \frac{Q_{add}}{\dot{m}_f} = \frac{697674.418}{25.974} = 26860.49 \ kJ/kg_f$$

$$Q_f = \dot{m}_f \cdot HV = (1-0.14-0.11) * 44000 = 33000 \ kJ/kg_f$$

$$N_2\% = 100 - 13.78 - 4.49 - 0.75 = 80.98\%$$

$$A/F) = \frac{C\% * N_2\%}{33(CO\% + CO_2\%)} = \frac{85(1-0.14-0.11) * 80.98}{33(0.75 + 13.78)}$$

$$= 10.766 \ kg_{air}/kg_f$$

$$\dot{m}_g = A/F + 1 - R - M - 9H_2$$

$$= 10.766 + 1 - 0.12 - 0.14 - 9(1-0.14-0.11) * 0.057$$

$$= 11.12 \ kg_g/kg_f$$

$$Q_g = \dot{m}_g C_{p_g} (T_{g_o} - T_{g_i}) = 11.12 * 1.05 * (288 - 50)$$

$$= 2779.765 \ kJ/kg_f$$

(

$$m_{s_1} = H + 9H_2 = 0.14 + 9 * (1 - 0.14 - 0.11) * 0.057$$

$$= 0.52475 \ kg_w / kg_f$$

$$h_s - h_w = 2837.9$$

$$\therefore Q_{s_1} = m_{s_1} (h_s - h_w) = 0.52475 * 2837.9 = 1489.188 \ kj/kg$$

$$W = \frac{0.622 \ P_{par}}{P_{at} - P_{par}} = \frac{0.622 * 0.0617}{0.942 - 0.0617} = 0.0436 \ kg_{H_2O} / kg_{air}$$

$$Q_v = A/F \ W \ C_{p_{w}} (T_{go} - T_{gi})$$

$$= 10.766 * 0.0436 * 1.926 * (288 - 50)$$

$$= 215.166 \ kJ / kg_f$$

$$m_{Co} = \frac{C_b * Co\%}{Co\% + Co_2\%} = \frac{(1 - 0.11 - 0.14) * 0.85 * 0.75}{0.75 + 13.78}$$

$$= 0.0304 \ kg / kg_f$$

$$Q_{co} = m_{Co} * 23630 = 0.0304 * 23630 = 777 \ kj/kg_f$$

$$Q_{furnace} = Q_f - [Q_r + Q_g + Q_{s_1} + Q_v + Q_{co}] = 878.679$$

Q_4 [10 Marks]

$P_t = P_b - P_v = 764 - 680 = 84$ mm Hg

$P_t = 0.084 * 13600 * 9.81 = 11.206$ kp

$P_t = P_s + P_a$

$P_s = P_{sat}$ at $t = 36.2$ $\quad P_s = 6.05$ kp

$P_a = P_t - P_s = 5.155$ kPa

$$\eta_v = \frac{P_{at} - P_t}{P_{at} - P_s} = \frac{101.928 - 11.206}{101.928 - 6.05} = 94.622\%$$

$PV = mRt$

$$V = \frac{1.78 * 287 * (36.2 + 273)}{5.155 * 10^3} = 30.641 \ m^3$$

Q_5 [10 marks]

Data :- $\alpha_1 = 20^\circ$ $C_1 = 375\ m/s$ $U = 165\ m/s$

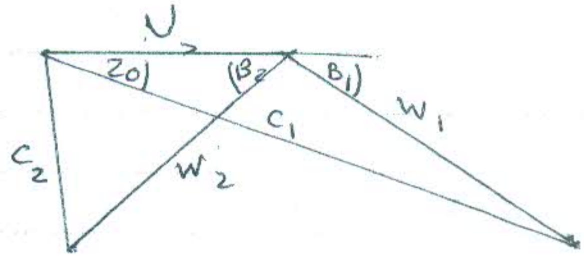
$C_{f_1} = C_{f_2}$ $F_c = 0$ $K = 0.85$ $m'_{st} = 1\ kg/s$

Req :

β_1 / β_2 / Power / $m'_{st}\ \frac{C_2^2}{2}$

Sol^n

scale 1 cm = 50 $\frac{m}{s}$



$U = \frac{165}{50} = 3.3\ cm$

$C_1 = \frac{375}{50} = 7.5\ cm$

$W_1 = 4.6\ cm = 230\ m/s$

$K = \frac{W_2}{W_1} = 0.85$

$W_2 = 0.85\ W_1 = 195.9\ m/s = 3.91\ cm$

$\beta_1 = 35^\circ$ $\beta_2 = 41^\circ$

$W_c = 6.8\ cm = 340\ m/s$

$Power = m'_{st} \cdot W_c \cdot U = 1 * 340 * 165 = 56.1\ kJ/s$

$C_2 = 2.65\ cm = 132.5\ m/s$

$m'_{st} * \frac{C_2^2}{2} = 8778.125 * 10^{-3} = 8.778\ kJ/kg$