Time: Three Hours ***Only Steam tables and Chart are allowable***

Q1 **(30 points)**

1-1)

1-2)

a. Thermal efficiency ?

Point 1 ,, P1 = 5 KPa (Sat. Liquid)

$h1 = h_F = 640.185$ Kj/Kg

Point 2 ,, P2 = 0.2 Mpa

$h2 = h1 + W_{P1} = h1 + 0.001\ (P2 – P1) = 640.185 + 0.001(200 - 5) = 640.83$ Kj/Kg

Point 3 ,, P3 = 0.2 MPa = 2 bar (Sat. Liquid)

$h3 = h_F = 504.684$ Kj/Kg

Point 4 ,, P4 = 15 Mpa = 150 bar

$h4 = h3 + W_{P2} = h3 + 0.001\ (P4 – P2) = 504.684 + 0.001(15000 - 200) = 519.484$ Kj/Kg

Point 5 ,, P5 = 15 Mpa = 150 bar (Sat. Liquid)

$h5 = h_F = 1610.15$ Kj/Kg

Point 6 ,, P6 = 15Mpa = 150 bar , T6 = 600 ^oC

h6 = 3310.79 Kj/Kg , S6 = 6.3479 Kj/Kg.K

Point 7 ,, P7= 1 MPa = 10 bar , S6 = S7 = 6.3479 Kj/Kg.K

From table 3 or Chart , h7 = 762.683 Kj/Kg

Point 8 ,, P8 = 1 MPa = 10 bar , T8 = 500 ^oC

From table 3 , h8 = 3449 Kj/Kg , S8 = 7.7640 Kj/Kg.K

Point 9 ,, P9 = 0.6 MPa = 6 bar , S9 = S8 = 7.7640 Kj/Kg.K

From table 3 or chart h9 = 3356 Kj/Kg

Point 10 ,, P10 = 0.2 MPa = 2 bar , S10 = S8 = 7.7640 Kj/Kg.K

From table 3 or chart h10 = 3010 Kj/Kg

Point 11 ,, P11 = 5 Kpa = 0.5 bar , S11 = S8 = 7.7640 Kj/Kg.K

From table 3 or chart h11 = 2720 Kj/Kg

Point 12,13 ,,, P=0.6 MPa = 6 bar (Sat. Liquid)

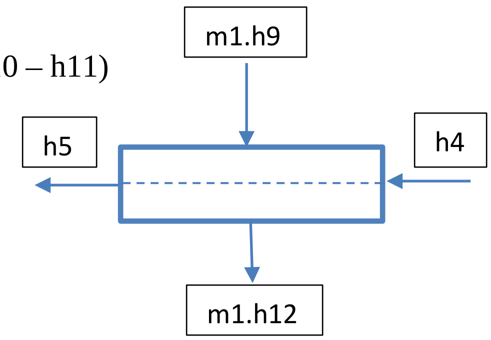
hF= h12 = h13 = 2756.2 Kj/Kg

$\eta_{th} = \frac{Wnet}{Qin}$

Q_{in} = (h6 – h5) + (h8 – h7)

W_{in} = (h6 – h7) + (h8 – h9) + (1- m)(h9 – h10) + (1 – m_1 – m_2)(h10 – h11)

* Balance Closed Feed Water



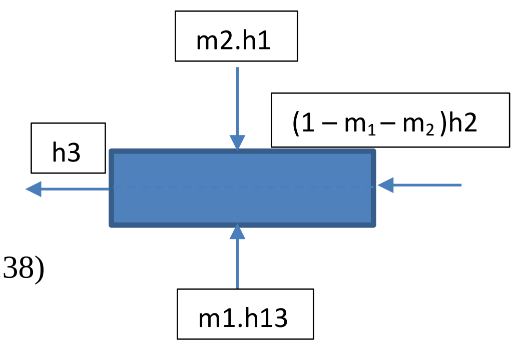
h5 + m1.h12 = h4 + m1.h9

m1(h9 – h12) = h5 – h4

m1 (3356 – 2756.2) = 1610.15 - 519.484

m1 = 1.81838

* Balance Open Feed Water



h3 = m2.h10 + m1.h13 + (1 – m_1 – m_2)h2

h3 = m2.h10 + m1.h13 + h2 – m1.h2 – m2.h2

m2(h10 – h2) = h3 – h2 – m1 (h13 – h2)

m2 (3010 – 640.38) = 504.684 – 640.38 – 1.81838(2756.2 – 640.38)

m2 =

Q2 (25 points)

2-1) Define and show the limitation of each statement?

1) Load Factor (LF)

It is defined as the ratio of the average load to the peak load during a certain prescribed period of time. It is always less than unity.

2) Utility Factor (UF)

It is the ratio of the units of electricity generated per year to the capacity of the plant installed in the station.

3) Demand Factor (DF)

This ratio of the maximum demand of a system to its connected load is termed as demand factor. It is always less than unity.

2-2) A generation station gas a maximum demand of 80 MW, a load factor of 65%, a plant capacity factor of 40% and a plant use factor of 85% find:

1) Daily energy produced.

2) Reserve capacity of plant.

3) The maximum energy that could be produced daily if the plant was running all the time.

4) The maximum energy that could be produced daily if the plant was running as per operating schedule.

2. A generating station gas a maximum demand of 80MW, a load factor of 65%, a plant capacity factor of 40% and a plant use factor of 85%. Find:

a.Daily energy produced.

b.Reserve capacity of plant.

c.The maximum energy that could be produced daily if the plant was running all the time.

d.The maximum energy that could be produced daily if the plant was running as per operating schedule.

a. Average demand = Load factor * Maximum demand = 0.65 * 80MW
= 52MW
Daily energy produced = 52 * 24 = 1248MWh

b. Installed capacity = Average demand/ Plant capacity factor
= 52MW/ 0.4 = 130MW
Reserve capacity = Installed capacity – Maximum demand
= 130MW – 80MW = 50MW

c. Maximum energy that could be produced daily if it was running all the time = Installed capacity * 24 = 130 * 24 = 3120MWh

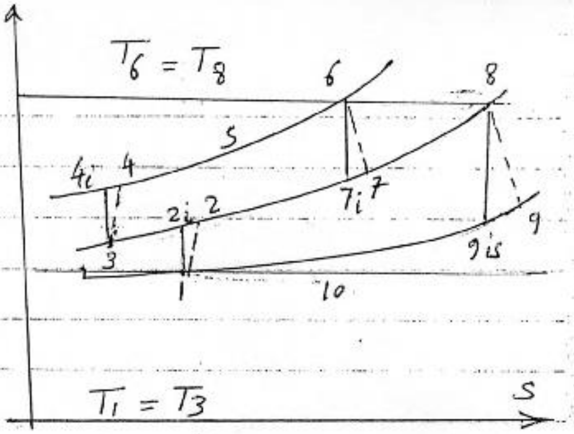
d. Maximum energy that could be produced daily if the plant was running as per operating schedule = Daily energy produced/ plant use factor
= 1248/ 0.85 = 1468.23MWh

Q3 **(25 points)**

3-1)

3-2)

Question (3)(b) 10



$T_1 = T_3 = 300\ K$

$T_6 = T_8 = 1400\ K$

$P_1 = 100\ Kpa$

$P_4 = P_5 = P_6 = 1000\ kpa$

$\dot{m}_{air} = 5.807\ Kg/s$

$P_2 = P_3 = 300\ kpa$

$T_2)_{is} = T_1 \left(\frac{P_2}{P_1}\right)^{\frac{\gamma-1}{\gamma}} = 410.6\ k$

$T_2 = T_1 + \frac{1}{\eta_c}(T_2)_{is} = 438.27\ K \quad \& \quad T_3 = T_1 = 300\ k$

$T_4)_{is} = T_3 \left(\frac{P_4}{P_3}\right)^{\frac{\gamma-1}{\gamma}} = 423.17\ K, \quad T_4 = T_3 + \frac{1}{\eta_{c_2}}(T_4)_{is} = 454$

$W_{T_{act}} = Cp \cdot \eta_{T_1} \cdot T_6 \left[1 - \left(\frac{1}{r_p}\right)^{\frac{\gamma-1}{\gamma}}\right] = 375.36\ kJ/kg$

$T_{7_{act}} = T_6 - \frac{W_{T_1}}{Cp} = 1074.6\ K \quad \& \quad T_{7_{is}} = T_6 \left(\frac{1}{r_p}\right)^{\frac{\gamma-1}{\gamma}} = 1038.5\ K$

$W_{T_2})_{act} = C_p\, T_8\, \eta_{T_2}\left[1 - \left(\frac{1}{rp}\right)^{\frac{\gamma-1}{\gamma}}\right] = 347.8\ kJ/kg$

$T_9)_{act} = T_7 = 1400 - \frac{347.8}{1.536} = 1099.4\ k \quad \& \quad T_{9})_{is} = T_8 \left(\frac{P_9}{P_8}\right)^{\frac{\gamma-1}{\gamma}} = 1066\ K$

$T_5 = T_4 + 0.85 \times \frac{Cp_g}{Cp_{air}} = (T_9 - T_4) = 1084.6\ K$

$Q_{Add} = Cp[(T_6 - T_5) + (T_8 - T_7)] = \boxed{643\ kJ/kg}$

$W_T = W_{T_1} + W_{T_2} = \boxed{723.16\ kJ/kg}$

$W_C = W_{C_1} + W_{C_2} = Cp[(T_2 - T_1) + (T_4 - T_3)] = \boxed{278.2\ kJ/kg}$

$W_{net} = W_T - W_C = \boxed{444.96\ kJ/kg}$

$\eta_{th} = W_{net}/Q_{Add} = 0.692 = \boxed{69.2\ \%}$

$\text{Work ratio} = W_{net}/W_T = \boxed{0.6153}$

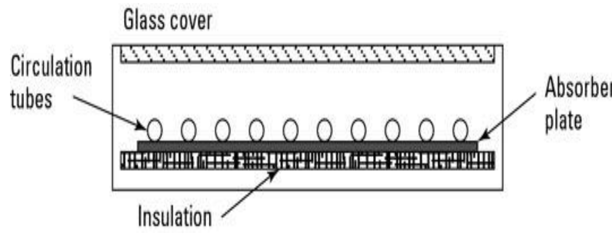
$\text{power} = \dot{m}_{air} \times W_{net} = 5.807 \times 444.96 = \boxed{2.5839\ MW}$

Q4 **(20 points)**

4-1) Explain briefly with drawing the types of solar energy collectors that can be used for low temperature limits?

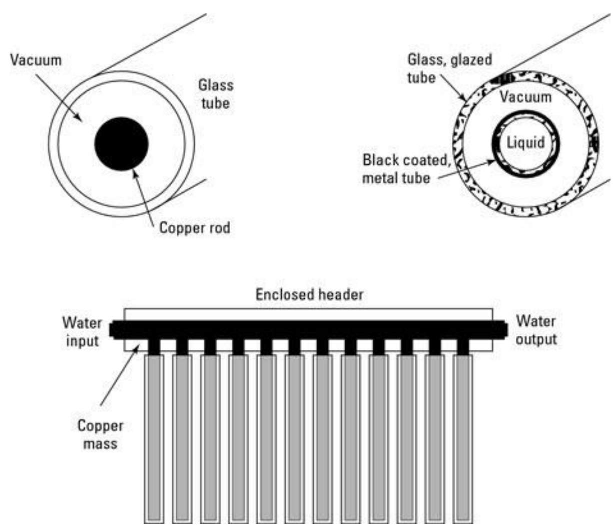
1. Flat plate Collectors

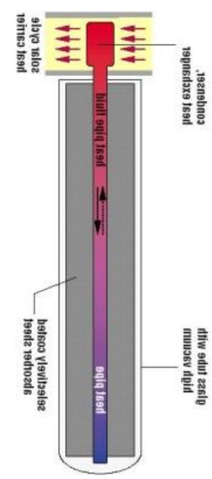
Flat plate collectors, where temperatures below about 90oC are adequate as they are for space and service water heating flat plate collectors, which are of the non-concentrating type, are particularly convenient. There are many flat-plate collector designs, but most are based on the principle shown in figure up. It is the plate and tube type collector. It basically consists of a flat surface with high absorptivity for solar radiation called the absorbing surface.



2. Evacuated-tube collectors

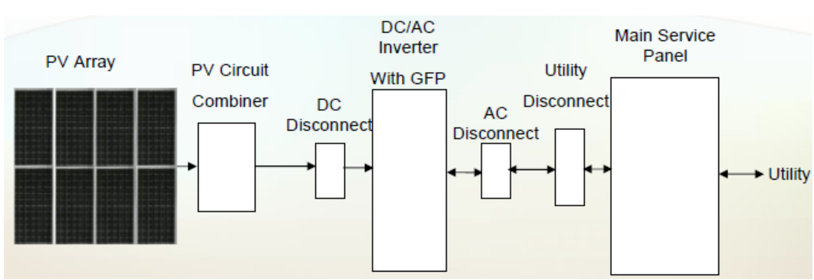
Convection heat loss due to air movements inside the collector can be significantly reduced by maintaining a vacuum between the front cover and the absorber of a flat plate collector.



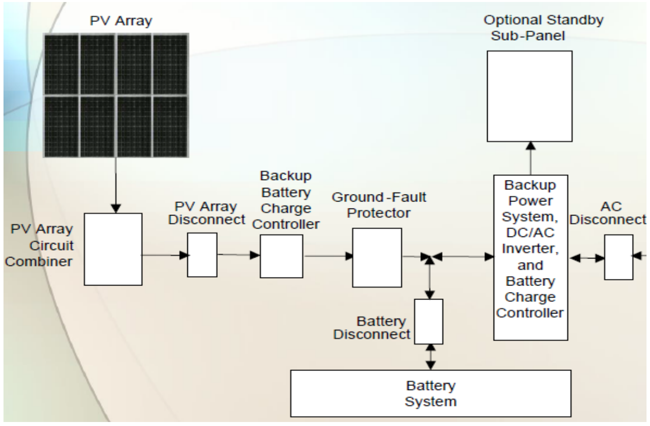


4-2) Compare between the different types of photovoltaic solar systems (operation, equipment and advantage) with drawing.

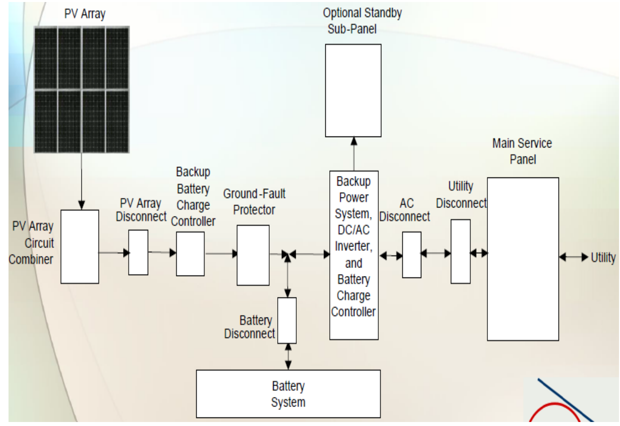
1. Grid-Tied Solar Systems



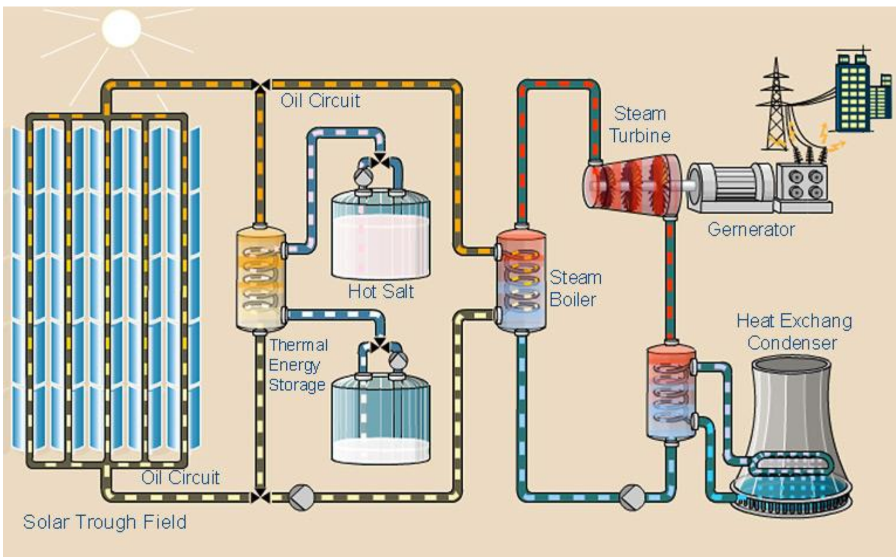
2. Off-Grid Solar Systems



3. Hybrid Solar Systems



4-3) Explain with drawing, components of steam power plant depend on concentrating solar thermal energy system and thermal storage tanks?



With best wishes
Dr. Mohamed Ramadan