Birla Institute of Technology and Science, Pilani

I Semester, 2023-24

Dated: 13/10/2023 Open Book

ME F420 Power Plant Engineering

Time: 90 Minutes Mid semester examinations

Marks : 30 Marks Weightage: 30%

Steam Tables and Psychometric chart permitted.

Part A **[5x2=10Marks]**

Q1) A 660MW power plant having specific steam consumption of 2kg/kWh operates at a condenser pressure of 50kPa and steam leaves the turbine at dry saturated condition. Due to decrease in atmospheric temperature, the power plant authorities decided to operate the condenser at a reduced pressure of 30kPa.Find the increase in power output from the turbine and additional revenue generated by the power plant if the selling price of one unit is Rs.8/-.(Assume isentropic expansion from 50kPa to 30KPa for simplicity sake.) Use the table given below.

P_S kPa	T_S ^OC	hf kJ/kg	hfg kJ/kg	Sf kJ/kgK	Sfg kJ/kgK
30	69.10	289.21	2336.1	0.9439	6.8247
50	81.33	340.47	2305.4	1.091	6.5029

Q2) Why Circulation Ratio in the water wall tubes in sub critical power plants are maintained above 6:1? Explain the effect of increasing the circulation ratio on the compactness of the boiler dimension with proper justification.

Q3) How will you differentiate the lignite fired boiler from the Anthracite fired boiler having identical operating parameters by the site inspection without doing coal analysis? Justify your answer. Also compare these boilers in terms of ash generated/ kWh.

Q4) Why the range of condensers used in hot and humid climatic conditions are lower than dry and hot climatic conditions? Explain with suitable psychometric process in the chart.

Q5) Why the high pressure and supercritical boilers are essentially forced circulation boilers while process boilers are of natural circulation type? Justify with suitable plot.

Part B **[4x5=20 Marks]**

Q6) It is proposed to operate a 660MW capacity power boiler uses Indian coal and Imported coal blended exactly in the ratio of 1:1 in order to reduce the coal cost. Composition of Indian and Imported coal by gravimetric analysis is given blow:

Coal	C %	H %	N %	S %	O %	A %	Cost of Coal
Indian	41.1	2.76	1.22	0.41	9.89	Remaining	₹2500/T
Imported	58.96	4.16	1.02	0.56	11.88	Remaining	₹3500/T

If the overall efficiency of the power plant is 42%, Find out whether blending of the coal will really lead to cost saving instead of using Indian or Imported coal alone.

Q7) Economiser of a 800MW capacity power plants takes saturated water from the condenser pressure of 50kPa and heats it to saturated water at boiler pressure of 200bar. Tubes are made up of 3.75cm ID and 5mm thickness. Entry velocity of the water to the tube is 1m/s. Overall HTC of the unit is 150W/m^2K. Flue gas undergoes temperature drop from 650^{O}C to 450^{O}C in the economizer. SSC of the power plant is 2kg/kWh. Find the number of tubes and length of each tube required. If he pump work is considered in designing the economiser, will it lead to significant change in the dimension? Justify your answer.

P_S kPa	T_S ^{O}C	h_f kJ/kg	h_{fg} kJ/kg	S_f kJ/kgK	S_{fg} kJ/kgK
20,000	365.75	1826.6	585.5	4.0106	0.9164
50	81.33	340.47	2305.4	1.091	6.5029

Q8) Air cooled condenser is used in a captive power plant of 25MW capacity in an acute water shortage locality. Saturated steam condenses at 50kPa (Use the data given in the previous problem). Air undergoes temperature increase from 30^{O}C to 40^{O}C. Overall HTC is 90W/m^2K. Find the total surface area required for the condenser and the air flow rate required. If the airside pressure drop in the condenser is 100mmWC find the power required to run the fan. Take the specific steam consumption of the power plant as 5kg/kWh. If similar plant is located in a place with adequate water and surface condenser is used with HTC of 1500W/m^2K, Find the percentage reduction in the area required. Take the temperature raise of the water and air as the same.

Q9) Super critical power plant of 800MW capacity operates with the SCC of 0.5kg/kWh using the imported coal having the composition given Q6. Sub critical power plant of 500MW of having SCC of 0.9kg/kWh uses Indian coal having composition as given in Q6. Compare the CO_2, SO_2 and Particulate matter emission per unit of power generated from the two power plants. Also find out the SCC, NPHR and overall efficiency of the two power plants.

Part B (Suggested time 60 minutes) **[3x10-30M]**

Q11) A 20cm long and 5mm diameter copper rod (K=330W/mK) is uniformly generating heat at a rate of 1MW/m^3 only for the first 10 cm length . This part of the rod is perfectly insulated on all the sides. Remaining 10cm length of the rod is exposed to convective environment having heat transfer coefficient of 25W/m^2K and exposed to atmosphere at 25^{O}C. Neglecting the heat loss from the two ends of the rod, find out the heat loss from the rod and the temperature distribution along the entire length of the rod. Assume 1D steady state conduction.

Q12) Oranges are assumed to be of spherical shape having 6cm diameter. They are initially at 28^{O}C. (K=0.45W/mK and α= 1.3x10^{-7}m^2/s). Center of the orange is to be cooled to 4^{O}C for long term preservation. It is done by passing cooled air at -4^{O}C over it at a velocity of 0.3m/s leading to heat transfer coefficient of 30W/m^2K. Find the time required for the center of the orange to attain the required preservation temperature. Also find whether any part of the orange will freeze during the process of cooling within this time. If so find the radius up to which the orange will not freeze.(Freezing occurs at 0^{O}C).

Q13) Parabolic concentrating collector tubes made of copper used for solar thermal applications can withstand maximum temperature of 475^{O}C only. At a given location the solar heat flux during the peak summer can be 1200W/m^2. Concentration ratio of the collector is 20. Concentration ratio is defined as the heat flux at the absorber tube to the flat surface. Find the minimum velocity of the heat transfer fluid (HTF) required to ensure the temperature of the copper tube does not increase beyond the tolerable limit if the maximum exit temperature of the fluid is 450^{O}C. Property values of Heat Transfer fluid are: Density =700kg/m^3, K=0.078W/mK,

Cp=2.6kJ/kgK, Dynamic viscosity=0.15×10^{-3}Ns/m^2. Diameter of the tube is=5cm with negligible thickness.