M.E. MECHANICAL ENGINEERING FIRST YEAR FIRST SEMESTER 2024

Steam Generators

Time: 3 hours Marks: 100

*Question number **Q1 is compulsory** and answer any four questions from the rest. Different parts of the same question should be **answered together**. Assume any relevant data if necessary. Use of Steam tables and charts are allowed*

Q1. *Answer the following questions*: 20

a) How do you determine dew point temperature of exhaust flue gas?

b) Why and when the downcomers placed outside the furnace?

c) Why a *CURTAIN* wall is provided in a large capacity pulverised fuel fired furnace?

d) Why are economizer tubes often finned or grilled on the gas side?

Q2. a) What do you mean by hard water? Why is trisodium phosphate injected into the drum? 5

b) Explain in details the working of a demineralized plant. 15

Q3. a) Explain-'*Coal with a high volatile matter is ignited easily*'. 5

b) A steam generator operates under the following conditions: Coal analysis: carbon 60.0, hydrogen 4.0, nitrogen 2.0, sulphur 1.5, oxygen 3.0, moisture 4.5 and ash 25.0. Dry flue gas analysis: CO_2, 12.0, CO 1.5, O_2 7.0 and N_2 79.5%. Steam condition at boiler outlet: 100 bar, 500°C, Feedwater inlet temperature: 170°C. Steam generation rate: 160 tonnes per hour, Steam generator efficiency: 85%, HHV of coal: 21 MJ/kg, Room temperature: 30°C, C_{pg} = 1.08 kJ/kgK, Determine (i) the excess air coefficient, (ii) the fuel burning rate, (iii) the amount of dry flue gas produced per kg coal, and (iv) the dry exhaust loss per kg coal. If the pressure losses before and after the furnace are 500 mm and 800 mm of water gauge respectively, and the exhaust gas temperature is 160°C, find (v) the total power consumed by the FD and the ID fans having efficiencies 70% and 60% respectively. 15

Q4. a) Define and classify coal burners. 4

b) A 210 MW power plant has steam condition at boiler outlet as 150 bar, 550^0C and the condenser pressure is 0.1 bar. The boiler efficiency is 88 percent and calorific value of coal is 25 MJ/kg. The feedwater temperature at boiler inlet is 170^0C.The steam generator has risers in the furnace wall 45 m high and unheated downcomers. The boiler operates on natural circulation and the circulation ratio is 16. A maximum exit velocity of water-steam mixture leaving a riser is required to be 1.7 m/s. The risers have 60 mm O.D and 3 mm thickness. Taking η_{gen}=0.94 and η_T=0.92 and neglecting any heat loss and pressure drop, as well as pump work, estimate (i) the steam generation rate, (ii) the fuel burning rate, (iii) the evaporation factor, (iv) the pressure head due to natural circulation, (v) the quality of the steam at the top of the riser, (vi) the number of riser required, (vii) the heat absorption rate per unit projected are a of a riser and (viii) the overall efficiency. 16

Q5. a) Explain the effect of load change on the exit steam temperature in convective and radiant superheaters. 10

b) Explain the various methods of superheat steam temperature control. 10

Q6. a) What is a supercritical boiler? What are its merits and demerits? 8

b) Why is spiral water wall adopted over vertical wall in supercritical boilers? 6

c) "The flue gas temperature downstream of air preheater is kept 140-160^{0}C"---------- ----explain the statement. 6

Q7. Write short notes on the followings (***any four***): 20

a) Boiler circulation, b) Turbulent burner, c) Artificial draft, d) 3-element drum level controller, e) Recuperative air preheater.