M.E. Power Engineering 1st Year 1st Semester Exam, 2025

Subject : Power Plant Cycles and Systems **Time: 3 hrs.** **Full Marks: 100**

Group A: Cycles – Answer any three questions

1. a) Explain with proper justifications why the efficiency of a ultra-supercritical power plant operating at a pressure of 250 bar and steam temperature of 570°/570° C is higher than the subcritical power plants. Also explain the role of condenser pressure on the efficiency of the power plant. **(5+3)**

   b) Consider a steam power plant operated on Rankine cycle for which main steam pressure and temperature at the entry to the turbine are 130 bar and 530 °C, respectively. The condenser cooling water enters at 30 °C and 10 °C temperature rise is allowed for the cooling water across the condenser. The TTD of the condenser is 8 °C. The isentropic efficiency of the turbine and pump are 92% and 88%, respectively. Find the thermal efficiency, specific steam consumption and work ratio. **(12)**

2. Draw the flow diagram of a thermal power plant considering the following.

   i) Main steam from the final superheater outlet enters the HP Turbine and the exhaust of the HP Turbine goes back to the reheater for reheating.

   ii) Reheated steam flows to the LP Turbine and then to the condenser.

   iii) Condensate Extraction Pump (CEP) pumps the condensate from the condenser hotwell through a closed low pressure heater (LPH) to the deaerator.

   iv) From the deaerator, Boiler Feed Pump (BFP) pumps the feedwater back to the boiler through a high pressure heater (HPH)

   v) The extractions for the HPHs is taken from the CRH line and those for the deaerator and LPHs are taken from the LPT.

   vi) The drip of the HPH is cascaded backward to the deaerator and that of the LPH is cascaded backward to the condenser.

   Draw a **representative** T-s diagram for the above cycle considering the main steam pressure to be subcritical, main steam to be superheated, CRH steam to be superheated, reheat steam to have the optimum reheat pressure and same temperature as the main steam, TTD of the LPH to be positive and that of HPH to be negative, no drain cooling in closed heaters, steam quality at the LPT exit to be optimum and expansion and compression processes to be ideal.

   Answer the following –

   a) What are the main purposes of reheating and regeneration in steam power plant?

   b) What do you mean by optimum reheat pressure?

   c) What do you mean by optimum steam quality at LPT exit and why is it required?

   d) What is the significance of deaerator in the cycle? **(20)**

3. Consider an ideal steam regenerative Rankine cycle with two feedwater heaters, one closed and one open. Steam enters the turbine at 15.0 MPa and 550 °C and exhausts to the condenser at 10 kPa. Steam is extracted from the turbine at 3.0 MPa for the closed feedwater heater and at 0.4 MPa for the open one. The TTD of the closed feedwater heater is –2 °C while the extracted steam leaves it as saturated liquid. The drain from the closed heater is cascaded to the open heater.

   (i) Draw the flow diagram for the cycle and show it on the T-s and h-s plots.

   (ii) Determine the mass flow rate of steam at the turbine inlet for a net power output of 250 MW

(iii) Calculate the thermal efficiency of the cycle. **(20)**

4. a) Why reheating is done in a gas turbine plant? Find out the optimum condition at which a reheat gas turbine plant should operate to maximize its performance. **(2+6)**

   b) The following data refer to an open cycle gas turbine plant:

   Isentropic efficiency of the compressor = 85%, Isentropic efficiency of the turbine = 88%, Mechanical transmission efficiency = 99%, Pressure ratio = 12, Maximum cycle temperature = 1250 K, Combustion efficiency = 98%, Calorific value of fuel = 42.8 MJ/kg, Air flow rate = 18 kg/s, Ambient temperature and pressure = 300 K, 1 bar.

   Calculate the power output from the turbine and overall thermal efficiency. Assume no pressure drop in the combustion chamber and the specific heats of product gas to be equal to that of air. **(12)**

Group B: Systems (Answer any two questions)

5. a) Name the types of circulation in a steam generator and explain their functional differences with suitable sketches. What may happen if the circulation in the boiler fails? **(6+4)**

   b) What are the functions of steam drum in a steam generator? With the help of suitable diagram show the functioning of the steam drum. **(2+8)**

6. a) Draw a neat schematic to show the air and flue gas flow systems in a thermal power plant. Name the different fans used in the air and flue gas systems and state their functions. **(5+5)**

   b) Draw the pressure distribution in the air and flue gas systems for a balanced draft. From it explain the benefits of balanced draft. **(4)**

   c) Show with a sketch the primary air supply to a pulverizer in a unit pulverizer system and explain the logic of its flow control. **(6)**

7. a) How the turbine glands are sealed and why is the sealing necessary? With a neat sketch explain the sealing system of turbines. **(4+6)**

   b) What is gland steam condenser and why is it provided in the system? **(4)**

   c) What are the justifications of HP-LP bypass lines? Where do you require the de-superheating in HP-LP bypass and why? – explain with suitable h-s plot. **(2+4)**