BACHELOR OF ENGINEERING (MECHANICAL ENGINEERING)
FOURTH YEAR FIRST SEMESTER EXAM 2019

Advanced Power Generation

Time: Three hours (*Answer any **FIVE** questions*) Marks: 100

Different parts of the same question should be answered together. All symbols carry their usual meanings unless otherwise mentioned. Assume any relevant data if necessary.

1. a) What do you understand by load factor and capacity factor? When they are numerically equal? 5

   b) Explain the effect of load factor on cost per kWh electricity generation. 5

   c) A power plant has the following annual factor: load factor 0.85, capacity factor 0.60, and use factor 0.65. Maximum demand is 80 MW. Estimate (i) the annual energy generation, (ii) the reserve capacity over and above the peak load, and (iii) the hours during which the plant is not in service per year. 10

2. a) The net power output of an ideal reheat regenerative steam cycle is 80MW. Steam enters the high pressure turbine at 80bar, 500^0C and expands till it becomes saturated vapour. Some of the steam then goes to an open feed water heater and the balance is reheated to 400^0C, after which it expands in a low pressure turbine to 0.07bar. Compute (a) the reheat pressure, (b) the steam flow rate to the high pressure turbine (c) the cycle efficiency and (d) the rate of flow of cooling water in the condenser if the temperature rise of water is 8^0C (e) if the velocity of steam flowing from the turbine to the condenser is limited to 130m/s, find the diameter of the connecting pipe. 15

   b) Explain the effect of regeneration on steam power cycle output and efficiency. 5

3. a) Discuss the advantages of combined cycle power generation. Why is it so important in the present day power scenario? 5

   b) A combined cycle power plant has a total power output of 300MW. The gas turbine operates with a pressure ratio of 10, air inlet temperature of 30^0C and the maximum gas temperature is 1000^0C. There is the provision for supplementary firing in which the combustion of additional fuel raises the gas temperature to 900^0C. The exhaust gas from the GT flows to a HRSG from which the gas leaves at 110^0C. In the bottoming cycle stem plant, the steam is supplied to the turbine at 80bar, 500^0C and the condenser pressure is 0.1 bar. The calorific value of fuel burned is 43.2 MJ/kg. Neglect the effect of the mass flow rate of fuel on the air flow and take c_p=1.11kJ/kgK

and γ=1.33 for combustion gases and c_p=1.005kJ/kgK and γ=1.4 for air. Neglect pump work. Draw the flow and T-s diagrams of the combined plant. Determine (i) the flow rates of air and steam supplied, (ii) the power outputs of the gas turbine and steam turbine (iii) the overall efficiency of the combined plant, and (iv) the air-fuel ratio. 15

4. a) Explain with neat sketches a cogeneration plant with adjustable loads. 8

   b) Steam enters the turbine at 7 MPa and 500°C. Some steam is extracted from the turbine at 500 kPa for process heating. The remaining steam continues to expand to 5 kPa. Steam is then condensed at constant pressure and pumped to the boiler pressure of 7 MPa. At times of high demand for process heat, some steam leaving the boiler is throttled to 500 kPa and is routed to the process heater. The extraction fractions are adjusted so that steam leaves the process heater as a saturated liquid at 500 kPa. It is subsequently pumped to 7 MPa. The mass flow rate of steam through the boiler is 15 kg/s. Disregarding any pressure drops and heat losses in the piping and assuming the turbine and the pump to be isentropic, determine (a) the maximum rate at which process heat can be supplied, (b) the power produced and the utilization factor when no process heat is supplied, and (c) the rate of process heat supply when 10 percent of the steam is extracted before it enters the turbine and 70 percent of the steam is extracted from the turbine at 500 kPa for process heating. 12

5. a) Explain operating principle of a Fuel cell neat schematic diagram. 8

   b) How fuel cells are classified? Explain briefly. 12

6. a) What do you mean by anaerobic digestion process? 6

   b) Explain different factors affecting digestion process. 8

   c) How gasifiers are classified? 6

7. Write short note on (any ***TWO***) 2 X 10 = 20 20

   a) Super critical technology

   b) Factors affecting gasification process

   c) Merits and demerits of super-critical technology