BACHELOR OF ENGINEERING (MECHANICAL ENGINEERING)
FOURTH YEAR FIRST SEMESTER EXAM 2025

Advanced Power Generation

Time: 03 hours (*Answer any **FIVE** questions*) Marks: 100

Different parts of the same question should be answered together. Use of steam tables are allowed. Assume any relevant data if necessary

1. a) Define Capacity factor. Also show that Capacity factor is the product of Load factor and Use factor. 4

   b) Explain the principle of economic scheduling. 7

   c) A thermal power plant consists of two 60 MW units, each running for 8000 hours, and one 30 MW unit running for 2000 hours per year. The energy produced by the plant is 876 $\times 10^6$ kWh per year. Determine the plant load factor and plant use factor. Consider the maximum load as equal to the plant capacity. 9

2. a) Why is the thermal efficiency of a condensing steam power plant less in a warm region than in a cold region? 5

   b) A steam power plant operates on an ideal reheat–regenerative Rankine cycle and has a net power output of 80MW. Steam enters the high-pressure turbine at 10 MPa and 550°C and leaves at 0.8 MPa. Some steam is extracted at this pressure to heat the feedwater in an open feed water heater. The rest of the steam is reheated to 500°C and is expanded in the low-pressure turbine to the condenser pressure of 10 kPa. Show the cycle on a *T-s* diagram with respect to saturation lines, and determine (*a*) the mass flow rate of steam through the boiler and (*b*) the thermal efficiency of the cycle 15

3. a) Why is the combined gas–steam cycle more efficient than either of the cycles operated alone? 5

   b) In a combined gas turbine-steam turbine plant, the exhaust gas from the gas turbine being the supply gas to the steam generator at which a further supply of fuel is burned in the gas. The pressure ratio for the gas turbine is 8, the inlet air temperature is 15^{0}C and the maximum cycle temperature is 800^{0}C. Combustion in the steam generator raises the inlet temperature of the exhaust gas from the gas turbine to 800^{0}C and the gas leaves the steam generator at 100^{0}C. The condition of steam at steam turbine inlet is 60 bar, 600^{0}C and the condenser pressure is 0.05 bar, Calculate the flow rates of air and steam required for total power output of 190 MW and the overall efficiency of the combined plant. Assume ideal processes. What would be the overall air fuel ratio? Take c_p of combustion gas and air as 1.11 and 1.005 kJ/kgK, and γ for gases and air as 1.33 and 1.4 respectively. Neglect the effect of mass flow rate of fuel on the air flow. Take the calorific value of the fuel as 43.3 MJ/kg. 15

4. a) What is cogeneration? Explain in brief a cogeneration plant. 8
   b) Steam enters the turbine of a cogeneration plant at 7 MPa and 500°C. One-fourth of the steam is extracted from the turbine at 600-kPa pressure for process heating. The remaining steam continues to expand to 10 kPa. The extracted steam is then condensed and mixed with feedwater at constant pressure and the mixture is pumped to the boiler pressure of 7 MPa. The mass flow rate of steam through the boiler is 30 kg/s. Disregarding any pressure drops and heat losses in the piping, and assuming the turbine and the pump to be isentropic, determine the net power produced and the utilization factor of the plant. 12
5. a) What is the distinct between air-blown and oxygen blown gasifiers? 10
   b) Explain an IGCC plant with the help of certain relevant blocks. 10
6. a) Draw and explain a supercritical boiler. 12
   b) State advantages of internally rifled tubes compared to smooth tubes in a supercritical boiler. 6
   c) Show a supercritical Rankine cycle with reheat on a *T-s* plane. 2
7. a) Define and classify fuel cell. 6
   b) Explain with neat sketch the working of a hydrogen-oxygen fuel cell system. 10
   c) What is a Faraday? What do you mean by the ideal voltage of a fuel cell? 4