Ref. No. : Ex/EE/5/ME/T/114/2024

B. E. (ELECTRICAL ENGINEERING) FIRST YEAR FIRST SEMESTER – 2024

PRIME MOVERS FOR ELECTRICAL SYSTEMS

Time: 3 hours **Full Marks: 100**

Instructions: Answer any five (5) questions. Assume any missing data with due reasoning.

1. (a) Describe the types of wind turbines with detailed sketches.

   (b) Prove that the theoretical maximum efficiency of an ideal wind turbine is 59.26% (8+12)

2. (a) What do you mean by the moving boundary work? Derive an expression for the work done by a polytropic process, given by the relationship between pressure (P) and volume (v) as $Pv^n=C$; here, n and C are constants.

   (b) Explain in detail the operating process of spark-ignition reciprocating engines. Draw the pressure-volume diagram and obtain an expression of its efficiency. (8+12)

3. (a) An engine working on the Otto cycle is supplied with air at 0.5 MPa at 45^0C. The compression ratio is 9, and the heat supplied is 2700 kJ/kg. Calculate the maximum pressure and temperature of the cycle. What is the cycle efficiency? Given, $C_{p,air}$=1.005 kJ/kg.K, $C_{v,air}$=0.718 kJ/kg K and R_{air}=287 J/kgK (where the symbols carry usual meanings).

   (b) Draw the pressure-volume diagram of the Diesel cycle and obtain an expression of its efficiency. (10+10)

4. (a) Describe in brief with a neat sketch of the working procedure of a steam power plant and obtain an expression of its efficiency.

   (b) A stream power plant operates on the simple ideal Rankine cycle where the steam enters the turbine at 3 MPa and 350^0C. The steam is then condensed in the condenser at a pressure of 75 kPa. Obtain the thermal efficiency of the cycle. At 75 kPa, enthalpy (h_f) and the specific volume (v_f) of the saturated liquid are 390.39 kJ/kg and 0.001127 m^3/kg. The enthalpy (h_g) and entropy (s_g) of saturated vapor at 3 MPa and 350^0C are 3115.3 kJ/kg and 6.7428 kJ/kg.K. At state point 4, the properties are: s_{f4}=1.22 kJ/kgK, s_{fg4}=6.7483 kJ/kgK, h_{f4}=390 kJ/kg, h_{fg4}=2300 kJ/kg. (10+10)

5. (a) Draw the pressure-volume and temperature-enthalpy diagrams of the Brayton cycle and obtain an expression of its efficiency.

   (b) A power plant operating on an ideal Brayton cycle has a pressure ratio r_p=10. The gas temperature is 310 K at the inlet of the compressor and 1500 K at the turbine inlet. Determine (i) the gas temperature at the compressor and turbine exits; (ii) obtain the thermal efficiency. (10+10)

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6. (a) Describe the general layout of a hydroelectric power plant with a neat sketch and indicate its different components.

   (b) A Pelton wheel has a mean bucket speed of 15 m/s and is supplied with water at 800 liters per second under a head of 40 m. If the bucket deflects the jet through an angle of 155^0, find the power developed by the turbine and its hydraulic efficiency. Assume the velocity coefficient is 0.97 and neglect the friction in the bucket. (8+12)

7. Write short notes on (a) Impulse and reaction turbines, (b) Enthalpy and entropy, (c) SI and CI engines, and (d) Wind turbines based on their rated capacities. (5+5+5+5)