Ref. No.: Ex/PE/PE/B/T/323C/2024

B.E. Power Engineering, 3rd Year, 2nd Semester Examination, 2024

IC Engine and Gas Turbine

Time: Three Hours **Full Marks: 100**

Group A: CO1 (30 Marks)

1. Answer the following questions briefly (any four questions)
   a) Define internal combustion engine and external combustion engine with applications.
   b) Briefly describe about the internal combustion engine components and their functions.
   c) Define Supercharged engine and Turbocharged engine.
   d) What are the differences between Four-stroke and Two-stroke SI Engines?
   e) State the advantages and disadvantages of the GT plant.

Marks: 4 × 4 = 16

2. Answer the following questions (any one question)
   a) For a dual cycle derive the expression of thermal efficiency $\eta = 1 - \frac{1}{r^{(\gamma-1)}}\left[\frac{r_p r_c^{\gamma} - 1}{(r_p - 1) + r_p \gamma (r_c - 1)}\right]$, where the symbols correspond to the usual meaning.
   b) Compare the performance of Otto, Diesel, and Dual cycles for the same inlet condition, peak pressure, and heat rejection (using P-V and T-S diagrams). Also shows the performance of Otto, Diesel, and Dual cycles under the same inlet condition, compression ratio, and heat rejection.

Marks: 1 × 14 = 14

Group B: CO2 (15 Marks)

3. Answer the following questions briefly (any three questions)
   a) What are the factors that affect the volumetric efficiency of a SI engine?
   b) What are the limitations of a simple carburetor?
   c) Why multiport fuel injection system (MPFI) is the most commonly adopted fuel injection system for modern petrol/gasoline engines?
   d) Describe the supercharged Otto cycle (using a P-V diagram).

Marks: 3 × 5 = 15

Group C: CO3 (30 Marks)

4. Answer the following questions (any two questions)
   a) An engine with an indicated thermal efficiency of 25% and mechanical efficiency 75 % consumes 25 kg/h of fuel at a fixed speed. The brake mean effective pressure is 5 bar and the mean piston speed is 15 m/s. Assuming that the engine is a four-stroke, single-cylinder, square engine, determine the crank radius and crank speed in RPM. Take CV of fuel = 42 MJ/kg.
   b) A four-stroke C.I. engine having a cylinder diameter of 39 cm and stroke of 28 cm has a mechanical efficiency of 80%. Assume the frictional power to be 80 kW. Its fuel

consumption rate is 86 kg/h with an air-fuel ratio of 18:1. The speed of the engine is 2000 RPM. Calculate (i) IP, (ii) HV, if η_{ith} = 40%, (iii) indicated mean effective pressure (p_{imep}) (iv) air flow rate, (v) mean piston speed.

c) An air-standard Dual cycle has a compression ratio of 10. The pressure and temperature at the beginning of compression are 1 bar and 27 °C. The maximum pressure reached is 42 bar and the maximum temperature is 1500 °C. Determine (i) the temperature at the end of constant volume heat addition (ii) cut-off ratio (iii) work done per kg of air and (iv) the cycle efficiency. Assume Cp = 1.004 kJ/kg K and Cv = 0.717 kJ/kg K for air.

Marks: 2 × 15 = 30

Group D: CO4 (10 Marks)

5. Answer the following questions briefly (any two questions)
   a) Describe the Brayton cycle with intercooling, reheat and regeneration (using TS diagram).
   b) Briefly describe about the main components of a gas turbine power plant.
   c) What are the differences between closed and open-cycle gas turbines (draw TS diagram).?

Marks: 2 × 5 = 10

Group E: CO5 (15 Marks)

6. Answer the following questions briefly (any one question)
   a) Air is supplied to a gas turbine plant at 1 kg/s. The pressure ratio is 6 and pressure at the inlet of the compressor is 1 bar. The compressor is of two stages and provided with a perfect intercooler. The inlet temperature is 300 K and the maximum temperature is limited to 1073 K. Isentropic efficiencies of a compressor and turbine are 80% and 85%, respectively. A regenerator is used in the plant of an effectiveness of 0.7. Neglecting the mass of fuel, determine the thermal efficiencies of the plant, *C*p of air is 1.005 kJ/kg·K.
   b) The following data refers to a gas turbine power plant
      Power developed = 5 MW,
      Inlet pressure and temperature of air to compressor = 1 bar and 303 K. Pressure ratio of the cycle = 5,
      Isentropic efficiency of the compressor = 80%,
      Isentropic efficiency of turbines = 85%,
      Maximum temperature of the cycle = 823 K,
      If a reheater is used between two turbines at a pressure of 2.24 bar, calculate the following:
      (a) Mass flow rate of air,
      (b) Overall efficiency, for air C_p = 1.0 kJ/kg/K, γ = 1.4.
      For gases, C_{pg} = 1.15kJ/kg/K, γ_g = 1.33.

Marks: 1 × 15 = 15