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B.E./B.Tech. DEGREE EXAMINATIONS, APRIL/MAY 2024.

Fourth Semester

Mechanical Engineering

ME 3451 – THERMAL ENGINEERING

(Common to : Mechanical Engineering (Sandwich))

(Regulations 2021)

Time : Three hours | Maximum : 100 marks

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. List two air standard cycle with t-s diagram.

2. Write any two key differences between the Carnot and Brayton cycles.

3. Define critical pressure ratio for steam flow through a nozzle.

4. Define impact of friction on steam flow through a nozzle.

5. List any two basic types of turbines used in power generation.

6. Write the significance of velocity diagram.

7. What is the significance of piston ring?

8. Interpret the significance of valve and port timing diagrams in engine operation.

9. Define morse test.

10. Write the effectiveness of implementing supercharging in internal combustion engine.

PART B — (5 × 13 = 65 marks)

11. (a) (i) The boiler produces dry and saturated steam at 30 bar. The steam expands in the turbine to a condenser pressure of 20 kPa. Compare the cyclic work done and thermal efficiency of Carnot and Rankine cycles for these conditions. (8)

(ii) A Diesel engine has an inlet temperature and pressure of 17°C and 1 bar, respectively. The compression ratio is 15 and the maximum cycle temperature is 1400 K. Calculate the air-standard efficiency of the Diesel cycle. Take $\gamma = 1.4$. (5)

Or

(b) (i) In an ideal Brayton cycle, air is compressed from 1 bar to a pressure ratio of 6. Calculate the cyclic efficiency. If the ratio of lower to upper temperature is 0.3 then calculate the work ratio. (6)

(ii) The pressure ratio and maximum temperature of a Brayton cycle are 5:1 and 923 K, respectively. Air enters the compressor at 1 bar and 298 K. Calculate for 1 kg of air flow, the compressor work, turbine work and the efficiency of the cycle. (7)

12. (a) (i) Explain the significance of critical pressure ratios in steam nozzles. (6)

(ii) Illustrate how variations in mass flow rate with pressure ratios impact the overall efficiency of the system. (7)

Or

(b) (i) A nozzle is to be designed to expand steam at the rate of 0.10 kg/s from 500 kPa, 210°C to 100 kPa. Neglect inlet velocity of steam. For a nozzle efficiency of 0.9, determine the exit area of the nozzle. (6)

(ii) Calculate the critical pressure and throat area per unit mass-flow rate of steam, expanding through a convergent-divergent nozzle from 10 bar, dry saturated, down to atmospheric pressure of 1 bar. Assume that the inlet velocity is negligible, and that the expansion is isentropic. (7)

13. (a) Discuss the principles of compounding and governing to optimize the performance of a gas turbine with its significance.

Or

(b) Compare regenerative, intercooled, and reheat cycles in terms of how each enhance gas turbine performance individually.

14. (a) Compare valve and port timing diagrams for internal combustion engines, highlighting differences in their operational characteristics and efficiency.

Or

(b) (i) Differentiate the operating characteristics of SI and CI engines by emphasizing the combustion processes, fuel delivery, and ignition mechanisms. (9)

(ii) Explain influence of each factor in engine performance. (4)

15. (a) An engine has a displacement of three liters and operates on a four-stroke cycle at 3600 RPM. The engine features a compression ratio of 9.5, square geometry (bore diameter is equal to the stroke length), and connecting rods with a length of 16.6 cm. Combustion concludes at 20° after TDC. The engine is connected to a dynamometer, registering a brake torque of 205 N-m at 3600 RPM. With air entering the cylinders at 85 kPa and 60°C, and a mechanical efficiency of 85%, calculate:

(i) Brake power

(ii) Indicated power

(iii) Brake mean effective pressure

(iv) Indicated mean effective pressure

Or

(b) Compare operating principles or supercharging and turbocharging by emphasizing the impact on air intake, combustion efficiency, and overall power output in internal combustion engines.

PART C — (1 × 15 = 15 marks)

16. (a) Design a steam nozzle for an industrial steam turbine operating at 30 bar inlet pressure and 500°C inlet temperature, with a mass flow rate of 5 kg/s, considering the effects of friction and variations in mass flow rate. Evaluate the performance of the designed nozzle in terms of critical pressure ratio for optimal efficiency and output.

Or

(b) Design p-v diagrams for both spark ignition (SI) and compression ignition (CI) engines, incorporating considerations for combustion processes and efficiency improvements.

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