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Question Paper Code : 21297

B.E./B.Tech. DEGREE EXAMINATIONS, NOVEMBER/DECEMBER 2023.

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. What is air standard cycle?

2. Draw the P-V and T-S diagram for ideal dual combustion cycle.

3. What do you mean by meta stable flow in steam nozzles?

4. What are the applications of convergence divergence nozzle?

5. Is it always useful to have a regenerator in a gas turbine power cycle. Why?

6. Write about dryness fraction of wet steam.

7. Comment on firing order of a multi-cylinder engine. How it is significant?

8. Draw the ideal and actual value-timing diagrams for a 4 stroke diesel engine.

9. What do you understand by the terms naturally aspirated and turbocharged in an engine?

10. Why emission testing is required in terms of performance evaluation of internal combustion engines?

PART B — (5 × 13 = 65 marks)

11. (a) The maximum pressure and temperature in an Otto cycle are 10 kPa and 27°C. The amount of heat added to the air per cycle is 1500 kJ/kg.

(i) Determine the pressure and temperatures and pressures at all points of the air standard Otto cycle.

(ii) Calculate the specific work and thermal efficiency of the cycle for a compression ratio of 8:1.

Take for air : C_v = 0.72 kJ/kgK and γ =1.4 .

Or

(b) In an engine working on Dual cycle, the temperature and pressure at the beginning of the cycle are 90°C and 1 bar respectively. The compression ratio is 9.2. The maximum pressure is limited to 68 bar and total heat supplied per kg of air is 1750 kJ. Calculate :

(i) Pressure and temperature at all salient points

(ii) Air standard efficiency

(iii) Mean effective pressure.

12. (a) Steam at a pressure of 10.5 bar and 0.95 dry is expanded through a convergent divergent nozzle. The pressure of steam leaving the nozzle is 0.85 bar. Find the velocity of steam at the throat for maximum discharge. Take n = 1.135. Also find the area at the exit and steam discharge if the throat area is 1.2 cm^2. Assume flow is isentropic and there are no friction losses.

Or

(b) Brief the following in case of steam nozzles :

(i) Critical pressure ratio

(ii) Effect of friction

(iii) Metastable flow and its effect.

13. (a) The gas turbine has an overall pressure ratio of 5:1 and the maximum cycle temperature is 550°C. The turbine drives the compressor and an electric generator, the mechanical efficiency of the drive being 97%. The ambient temperature is 20 he turbine drives the compressor and an electric 20°C and the isentropic efficiencies for the compressor and the turbine are 0.8 and 0.83 respectively. Calculate the power output in megawatts for an air flow of 15 kg/s. Also calculate the thermal efficiency and work ratio.

Neglect the changes in kinetic energy and loss of pressure in combustion chamber.

Or

(b) A steam power plant operates on an ideal reheat Rankine cycle between the pressure limits of 15 MPa and 10 kPa. The mass flow rate of steam through the cycle is 12kg/s. Steam enters both stages of the turbine at 500°C. If the moisture content of the steam at the exit of the low-pressure turbine is not to exceed 10%, determine the following.

(i) Reheat pressure

(ii) Heat input to the Boiler

(iii) Thermal efficiency of the cycle.

Represent the cycle on T-s diagram.

14. (a) What do you mean by knocking? Describe the phenomenon of knocking in SI engine. What are the factors affect the knocking? How can it be controlled?

Or

(b) Explain the different types of combustion chambers used in CI engines.

15. (a) A six cylinder, gasoline engine operates on the four stroke cycle. The bore of each cylinder is 80 mm and the stroke is 100 mm. The clearance volume per cylinder is 70 cc. At the speed of 4100 rpm, the fuel consumption is 5.5 gm/sec and the torque developed is 160 Nm. Calculate :

(i) Brake power

(ii) Brake mean effective pressure

(iii) Brake thermal efficiency if the calorific value of the fuel is 44000 kJ/kg and

(iv) Relative efficiency on a brake power basis assuming the engine works on the constant volume cycle $\gamma = 1.4$ for air.

Or

(b) During the trial of a four stoke, single cylinder, oil engine the following observations were recorded: bore = 300 mm. stroke = 400 mm, speed = 200 rpm, duration of trial = 60 minutes. fuel consumption = 7.050 kg, calorific value = 14000 kJ/kg, area of indicator diagram = 322 mm^2, length of indicator diagram = 62 mm, spring index = 1.1 bar/mm, dead load on the brake drum = 140 kg, spring balance reading = 5 kg, brake drum diameter =1600 mm, total weight of cooling water = 495 kg, temperature rise of cooling water = 38°C, temperature of exhaust gases = 300°C, air consumption = 311 kg; specific heat of exhaust gases = 1.004 kJ/kg K; specific heat of water = 4.186 kJ/kg K; room temperature = 20°C. Determine

(i) Brake power

(ii) Indicated power

(iii) Mechanical efficiency

(iv) Indicated thermal efficiency.

PART C — (1 × 15 = 15 marks)

16. (a) Explain normal and abnormal combustion in IC engines. List the factors affecting knocking phenomenon.

Or

(b) Write about scenarios of rich and lean mixture of as 4-storke IC engine, when the vehicle is travel from plain region to hilly region with clear pictures of fuel-air mixture.