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B.E./B.Tech. DEGREE EXAMINATIONS, NOVEMBER/DECEMBER 2022.

Fourth/Sixth Semester

Mechanical Engineering

ME 8493 — THERMAL ENGINEERING — I

(Common to Mechanical Engineering (Sandwich))

(Regulations 2017)

Time : Three hours | Maximum : 100 marks

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. Draw the P-V and T-s diagram for Diesel cycle.

2. List the four processes involved in air standard Brayton cycle.

3. How intercooling increases efficiency of compressor?

4. Differentiate between reciprocating and centrifugal compressor.

5. List the geometric differences between the 4-stroke and 2-stroke SI engine.

6. What are the desirable properties of fuel for CI engine?

7. Why multi point fuel injection system is needed for SI engines?

8. What is the need for emission norms? Name the emission norm followed now.

9. How performance of stationary gas turbine can be improved?

10. Why special alloys are used for turbine blades in a gas turbine?

PART B — (5 × 13 = 65 marks)

11. (a) In an air-standard Otto cycle, the pressure at the end of compression is 12 times that at the start, the temperature of air at the beginning of compression is 30°C and maximum temperature attained in the cycle is 1700°C. Determine

(i) Compression ratio (4)

(ii) Thermal efficiency (4)

(iii) Work done. (5)

Or

(b) The compression ratio and expansion ratio of an oil engine working on dual cycle are 9 and 5 bar respectively. The initial pressure and temperature of the air are1 bar and 30°C. The heat liberated at constant pressure is twice the heat liberated at constant volume. The expansion and compression follow the law $PV^{1.25}$ = constant. Determine

(i) Pressure and temperature at all salient points (7)

(ii) Mean effective pressure. (6)

12. (a) A single cylinder, single acting reciprocating air compressor runs at 300 rpm, is driven by a 23 kW electric motor. Mechanical efficiency of the drive between motor and compressor is 87%. Air inlet conditions are 1 bar and 15 °C and the delivery pressure is 8 bar. Calculate the free air delivery, volumetric efficiency, bore and stroke of the compressor. Assume that the index of compression and expansion as 1.3, the clearance volume is 7% of swept volume and that the bore is equal to the stroke.

Or

(b) A single acting two stage air reciprocating compressor delivers air at 18 bar. The temperature and pressure of air before the compression in low pressure cylinder are 25°C and 1 bar. The discharge pressure of low-pressure cylinder is 4.2 bar. The pressure of air leaving the inter-cooler is 4 bar and air is cooled to 25°C. The diameter and stroke of low-pressure cylinder are 40 cm and 50 cm respectively. The clearance volume is 5% of stroke volume in both the cylinders. The speed of compressor is 200 rpm. Assuming the index of compression and re-expansion in both the cylinders as 1.25 and Cp = 1.005 kJ/kg K, determine

(i) Power required to run the compressor (7)

(ii) Heat rejected in the intercooler per minute. (6)

13. (a) Describe about the construction of 4-stroke SI engine with a neat sketch.

Or

(b) Describe about the factors responsible for knocking in SI engines. Also discuss the factors responsible for knocking in Cl engines.

14. (a) With a neat sketch, brief about the construction of common rail direct injection system.

Or

(b) For a multi-cylinder engine, elaborate on the construction of water based cooling system employed in engines with supporting sketches.

15. (a) A closed cycle regenerative gas turbine operating with air as working medium has P_1 = 1.4 bar, T1 = 310 K, P_2/P_1 = 5, T_{max} = 1050 K, effectiveness of regenerator = 100%, net work output = 300C kW. Assuming the compression and expansion to be isentropic, determine

(i) Thermal efficiency and (7)

(ii) Mass flow rate of air per minute. (6)

Or

(b) In a gas turbine, the pressure ratio to which air at 15°C is compressed is 6. The same air is then heated to a maximum permissible temperature of 750°C . First in a heat exchanger and then combustion chamber. It is then expanded in two stages such that the expansion work is maximum. The air is reheated to 750°C after the first stage. Determine

(i) Thermal efficiency of the cycle (4)

(ii) Work ratio and (4)

(iii) Net shaft work per kg of air. (5)

PART C — (1 × 15 = 15 marks)

16. (a) During a test on a Diesel engine, the following observations were made: Power developed by the engine is used for driving a DC Generator. The output of the generator was 210 A at 200 V, efficiency of the generator = 82%. The quantity of fuel supplied to the engine was 11.2 kg/h, calorific value of fuel = 42600 kJ/kg. The air-fuel ratio was 18:1. The exhaust gases were passed through a exhaust gas Calorimeter for which, water circulated through the calorimeter = 580 litres/h, temperature rise of water flowing through the Calorimeter = 36 °C, temperature of exhaust gases at exit of the Calorimeter = 98°C, Heat lost to the jacket cooling water is 32% of total heat supplied. Take ambient temperature = 25°C and C_p of exhaust gases = 1.05 kJ/kg K. Draw the heat balance sheet on minute basis.

Or

(b) A 4-cylinder petrol engine has a bore of 57 mm and a stroke of 90 mm. Its rated speed is 2800 rpm and it is tested at this speed against a brake, which has a torque arm of 0.356 m. The net brake load is 155 N and the fuel consumption is 6.74 liters/h. Specific gravity of fuel used is 0.735 and it has a lower calorific value of 44200 kJ/kg. A Morse test is carried out and the cylinders are cut out in the order 1, 2, 3, 4 with the corresponding brake loads 111, 106.5, 104.2 and 111 N respectively. Determine

(i) Brake thermal efficiency (4)

(ii) specific fuel consumption (4)

(iii) Mechanical efficiency (4)

(iv) Indicated thermal efficiency. (3)