Code : 021722

B.Tech 7th Semester Exam., 2020

INTERNAL COMBUSTION ENGINE AND GAS TURBINE

Time : 3 hours *Full Marks* : 70

Instructions :

(i) The marks are indicated in the right-hand margin.

*(ii) There are **NINE** questions in this paper.*

*(iii) Attempt **FIVE** questions in all.*

*(iv) Question No. **1** is compulsory.*

1. Choose the correct answer of the following (any *seven*) : 2×7=14

(a) The intercooling in multistage compressor is done to

(i) cool the air during compression

(ii) cool the air at delivery

(iii) enable compression in two stages

(iv) minimize the work of compression

(b) In SI engine, the compression ratio ranges from

(i) 2 to 7

(ii) 8 to 12

(iii) 12 to 16

(iv) 15 to 20

(c) The expansion stroke pressures for real engine cycle fall below the fuel-air cycle because of which of the following reasons?

(i) Heat transfer from the burned gases to the walls

(ii) Finite combustion time

(iii) Exhaust blow down loss

(iv) All of the above

(d) Knock in SI engine can be reduced by

(i) supercharging

(ii) retarding spark timing

(iii) low-octane rating fuel

(iv) advancing spark timing

(e) The temperature below which separation of wax in diesel becomes visible is

(i) pour point

(ii) cloud point

(iii) flash point

(iv) acid point

(f) In a CI engine, the ignition delay

I. increases with increasing air inlet temperature

II. decreases with increasing inlet temperature

III. decreases with increasing speed

IV. decreases with increasing cetane number

(i) I, II and III are correct

(ii) II, III and IV are correct

(iii) I, II and IV are correct

(iv) All of the above

(g) With an increase in compression ratio, the indicated fuel conversion efficiency of Otto cycle

(i) increases

(ii) decreases

(iii) first increases then decreases

(iv) first decreases then increases

(h) Rotational flow of charge within the cylinder about its axis is known as

(i) squish

(ii) swirl

(iii) tumble

(iv) None of the above

(i) In comparison to spark ignition engines, compression ignition engines have

(i) higher part load mechanical efficiency and lower fuel conversion efficiency

(ii) higher part load mechanical efficiency and higher fuel conversion efficiency

(iii) lower part load mechanical efficiency and lower fuel conversion efficiency

(iv) lower part load mechanical efficiency and higher fuel conversion efficiency

(j) The factors which must be considered before deciding the optimum firing order of an engine are

(i) engine vibration

(ii) engine vibration and engine cooling

(iii) engine vibration and development of back pressure

(iv) engine vibration, engine cooling and development of back pressure

2. (a) Explain the valve timing diagram of SI and CI engine for 4-stroke engine. 7

(b) Explain why SI engine torque varies at fixed speed and inlet mixture conditions as the spark timing is varied from very advanced to close to TDC. What is the 'best' spark timing? Explain how it varies with engine speed and load. 7

3. *(a)* A diesel engine working on the air-standard diesel cycle takes air at a pressure of 1 bar and temperature 30 °C. The pressure at the end of compression is 30 bars and the cut-off is 6% of the stroke. Calculate—

   (i) the compression ratio;

   (ii) the percentage clearance;

   (iii) the heat supplied;

   (iv) the heat rejected;

   (v) the thermal efficiency;

   (vi) the mean effective pressure.

   Assume, $C_p = 1 \cdot 005$ kJ/kg K and $C_v = 0 \cdot 718$ kJ/kg K. 7

   (b) Define volumetric efficiency and discuss the various factors affecting the volumetric efficiency of an internal combustion engine. 7

4. *(a)* A four-cylinder, four-stroke gasoline engine working at 3000 r.p.m. develops a brake power of 21 kW. A Morse test was conducted on this engine and the brake power obtained when each cylinder was made inoperative by short circuiting the spark plugs are 15 kW, 14·2 kW, 14·7 kW and 14·4 kW

respectively. The Morse test was conducted at constant speed. Find the indicated power, mechanical efficiency and brake mean effective pressure when all the cylinders are firing. The bore and stroke of engine are 8 cm and 9 cm respectively. 7

(b) Explain why turbulence in mixture charge motion is necessary to operate petrol engine over a necessary speed range. Also, discuss the various methods used to induce swirl motion of air or mixture charge inside combustion chamber of an internal combustion engine. 7

5. *(a)* Explain clearly the various factors affecting the performance of a propulsion device. 7

   (b) A jet propelled plane consuming air at the rate of 18·2 kg/s is to fly at a Mach number 0·6 at an altitude of 4500 m ($p_a = 0 \cdot 55$ bar and $T_a = 255$ K). The diffuser which has a pressure coefficient of 0·9 decreases the flow to a negligible velocity. The compressor pressure ratio is 5 and maximum temperature in the combustion chamber is 1273 K. After expanding in the turbine, the gases

continue to expand in the nozzle to a pressure of 0·69 bar. The isentropic efficiencies of compressor, turbine and nozzle are 0·81, 0·85 and 0·915 respectively. The heating value of the fuel is 45870 kJ/kg. Assuming C_p=1·005 kJ/kg K, C_{pg}=1·147 kJ/kg K, γ_{air} = 1·4, γ_{gas} = 1·33, calculate—

(i) the power input to the compressor;

(ii) the power output of the turbine;

(iii) the fuel-air ratio;

(iv) the thrust provided by the engine;

(v) the thrust power developed. 7

6. *(a)* Derive an expression for the optimum pressure ratio giving maximum cycle thermal efficiency of gas turbine cycle, if the compressor efficiency is η_c and the turbine efficiency is η_t. The maximum cycle temperature is T_{max} and the minimum cycle temperature is T_{min}. 7

(b) In a gas turbine plant, the air at 10 °C and 1 bar is compressed to 12 bars with compression efficiency of 80%. The air is heated in a regenerator and the combustion chamber till its temperature is raised to 1400 °C, and during the process the pressure falls by 0·2 bar.

The air is then expanded in the turbine and passes to regenerator which has 75% effectiveness and causes a pressure drop of 0·2 bar. If the isentropic efficiency of the turbine is 85%, determine the thermal efficiency of the plant. Assume γ for air to be 1·4. 7

7. *(a)* Briefly discuss the air-fuel ratio requirements of a petrol engine from no load to full load condition. Describe the essential parts of a modern carburetor. 7

(b) How are injection systems classified? Describe them briefly. Why is the air injection system not used nowadays? 7

8. *(a)* With the help of a neat sketch, discuss the working principle of capacitive discharge ignition system. 7

(b) Describe the functions of the following components of an internal combustion engine :

Piston, Piston rings, Crankshaft,

Connecting rod, Flywheel, Camshaft

Also mention the materials used and methods of manufacture for these parts. 7

9. Write short notes on any *four* of the following : 14

(a) Adiabatic flame temperature

(b) Multipoint port fuel injection system

(c) Working principle of jet propulsion

(d) Combustion chamber design of CI engine

(e) Types of cooling system

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