2013

INTERNAL COMBUSTION ENGINES

AND GAS TURBINES

Time Allotted : 3 Hours *Full Marks* : 70

The figures in the margin indicate full marks.

Candidates are required to give their answers in their own words as far as practicable.

GROUP – A

(Multiple Choice Type Questions)

1. Choose the correct alternatives for any *ten* of the following :

$10 \times 1 = 10$

i) Combined cycle efficiency is around

a) 65% b) 59%

c) 47% d) 37%.

ii) Ideally what should be the MW ratio of power generation for a GTG : STG power plant ?

a) 1 : 2 b) 2 : 1

c) 1 : 3 d) 3 : 1.

iii) In reheat gas turbine cycle, the relation between the temperature ratios for optional work output is

a) $t=\sqrt{t_1 t_2}$ b)) $\sqrt{t}=t_1 t_2$

c) $t= \sqrt{t_1}= \sqrt{t_2}$ d) $\sqrt{t}=t_1=t_2$

iv) The work output of theoretical Otto cycle

a) increases with increase in compression ratio

b) increases with increase in pressure ratio

c) increases with increase in adiabatic index

d) follows all of these.

v) Stoichiometric air-fuel ratio by mass for combustion of petrol is

a) 5 b) 10

c) 12 d) 15·05.

vi) The fuel-air ratio, for maximum power of S.I. engines, should be

a) lean b) rich

c) may be lean or rich d) chemically correct.

vii) In S.I. engine, to develop high voltage for spark plug

a) battery is installed

b) distributor is installed

c) carburetor is installed

d) ignition coil is installed.

viii) In a 4-cylinder petrol engine the standard firing order is

a) 1-2-3-4 b) 1-4-3-2

c) 1-3-2-4 d) 1-3-4-2.

ix) The knocking tendency in petrol engines will increase when

a) speed is decreased

b) speed is increased

c) fuel-air ratio is made rich

d) fuel-air ratio is made lean.

x) Petrol commercially available in India for Indian passenger cars has octane number in the range

a) 40 to 50 b) 60 to 70

c) 80 to 85 d) 95 to 100.

xi) Desirable characteristic of combustion chamber for S.I. engines to avoid knock is

a) small bore

b) short ratio of flame path to bore

c) absence of hot surfaces in the end region of gas

d) all of these.

xii) The increase in the cut-off ratio of a Diesel cycle with

fixed compression ratio would

a) decrease *m.e.p.* b) increase *m.e.p.*

c) keep same *m.e.p.* d) none of these.

xiii) The highest flame speed is obtained with an air-fuel ratio

a) somewhat richer than chemically correct

b) stoichiometric

c) very rich

d) lean.

xiv) The most effective method of determining FHP for multicylinder engines is

a) Morse test b) Wilan's line test

c) mechanical indicator d) electronic indicator.

GROUP – B

(Short Answer Type Questions)

Answer any *three* of the following. 3 × 5 = 15

2. Briefly discuss about the important qualities of CI engine fuels.

3. Discuss the advantages of liquid-cooling of an internal combustion engine.

4. What is detonation ? Briefly discuss the factors that affect detonation.

5. Explain the ideal Joule cycle of gas turbine with the help of a block diagram and also show the processes in *P-V* and *T-s* diagrams.

6. What materials are used for gas turbine rotor discs, rotor blades and combustion chamber ? How is cooling done in gas turbine blades ?

7. What is repowering ? Draw and the layout of an Integrated Gasification Combined Cycle (IGCC) plant. Explain.

GROUP – C

(Long Answer Type Questions)

Answer any *three* of the following. 3 × 15 = 45

8. a) Differentiate between battery ignition system and magneto-ignition system. 5

b) In an oil engine, working on dual combustion cycle, the temperature and pressure at the beginning of compression are 90°C and 1 bar respectively. The compression ratio is 15 : 1. The heat supplied per kg of air is 1500 kJ, half of which is supplied at constant volume and half at constant pressure. Calculate —

i) the maximum pressure in the cycle.

ii) the percentage of stroke at which cut-off occurs.

Take γ for compression = 1·4; R = 0·287 kJ/kg K and C_v for product of combustion = $0{\cdot}71 + 20 \times 10^{-5}$.

10

9. a) Why is spark advance required in S.I. engines ? 2

b) Discuss the factors which influence flame-propagation in S.I. engines. 5

c) A sample jet carburetor is required to supply 5 kg of air per minute and 0·4 kg of fuel of density 750 kg/m^3. The air is initially at 1·013 bar and 25°C.

i) Calculate the throat diameter of the choke for a flow velocity of 85 m/s. Velocity coefficient is 0·8.

ii) If the pressure drop across the fuel metering orifice is 0·75 of that at the choke, calculate the orifice diameter assuming C_d = 0·60. 8

10. a) What is specific fuel consumption ? 1

b) What is ignition lag ? 1

c) The indicated thermal efficiency of a four-stroke engine is 32% and its mechanical efficiency is 75%. The fuel consumption rate is 21 kg/h running at a fixed speed.

The brake mean pressure developed is 5 bar and the mean speed is 12 m/s. Assuming it to be a single cylinder square engine, calculate the crank radius and the speed of engine. Take C_v = 42 MJ/kg. 5

d) The power output of a six-cylinder four-stroke engine is absorbed by a water brake for which the law is WN/20000, where the brake load, *W* is in newton and the speed, *N* is in rpm. The air consumption is measured by an air box with sharp edged orifice system. The following readings are obtained :

Orifice diameter = 30 mm, Bore = 100 mm, Stroke = 120 mm, Brake load = 560 N, C/H ratio by mass = 83/17, Coefficient of discharge = 0·6, Ambient pressure = 1 bar, Pressure drop across the orifice = 14·5 cm of Hg. Time taken for 100 cc of fuel consumption = 20 s, Ambient temperature = 27°C, Fuel density = 831 kg/m^3. Calculate —

i) the break power

ii) the torque

iii) the brake specific fuel consumption

iv) the percentage of excess air

v) the volumetric efficiency. 8

11. a) How can the improvement in a gas turbine cycle be made ? 3

b) Prove that for an actual constant pressure gas turbine cycle, $t_{opt} = \sqrt{\beta \eta_c \eta_T}$ where, t_{opt} = ratio of optimum temperatures in actual gas-turbine cycle, *b* = ratio of maximum and minimum temperatures of the gas turbine cycle, η_c = compressor efficiency and η_T = turbine efficiency. 12

12. a) In a constant pressure gas turbine cycle, the minimum

and maximum temperatures are 50°C and 950°C respectively. If the compressor and turbine efficiencies are 0·82 and 0·87 respectively, determine for maximum power output,

i) the pressure ratio of the turbine and compressor.

ii) the maximum power output per unit flow-rate.

iii) the thermal efficiency of the plant.

Assume for compressor and turbine both $\gamma = 1 \cdot 4$ and $C_p = 1 \cdot 005$ kJ/kg K. 7

b) Prove that for a gas turbine cycle with reheat and exhaust heat exchanger, thermal efficiency is given by

$\eta = 1-(t-1)/2\beta(1-1/t_1)$

Where, β = ratio of maximum temperature and minimum temperature, t = temperature ratio of the compressor and t_1 = temperature ratio of the HP cylinder of the turbine. 8

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