Total No. of Questions—12] [Total No. of Printed Pages—8

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S.E. (Mechanical) (First Sem.) EXAMINATION, 2010

APPLIED THERMODYNAMICS

(2003 COURSE)

Time : Three Hours **Maximum Marks : 100**

N.B. :— (*i*) Answer *three* questions from Section I and *three* questions from Section **II**.

(*ii*) Answer to the two sections should be written in separate answer-books.

(*iii*) Neat diagrams must be drawn wherever necessary.

(*iv*) Figures to the right indicate full marks.

(*v*) Use of logarithmic tables, slide rule, Mollier charts, electronic pocket calculator and steam tables is allowed.

(*vi*) Assume suitable data, if necessary.

SECTION I

UNIT I

1. (*a*) Explain Carnot cycle and derive the expression for its efficiency. Discuss the reasons, why Carnot cycle could not be practiced ? [8]

P.T.O.

(*b*) A Carnot heat engine operates between two heat reservoirs at temperatures of 725°C and 70°C. The engine drives a reversible refrigerator which operates between reservoirs at 70°C and –32°C. The heat transferred to the engine is 2500 kJ and the net work output of the combined engine—refrigerator unit is 425 kJ. Evaluate the heat transferred to the refrigerator and net heat transferred to the reservoir at 70°C. [8]

Or

2. (*a*) Show that entropy change in a polytropic process of an ideal gas : [6]

$$\Delta s = \left(\frac{\gamma - n}{\gamma - 1}\right) \mathrm{R} \ln \left(\frac{\mathrm{V}_2}{\mathrm{V}_1}\right) \quad \text{where } \gamma = \mathrm{C}_p / \mathrm{C}_v .$$

(*b*) State the "principle of increase in entropy" Explain with example. [4]

(*c*) A heat exchanger uses 5,000 kg/hr of water to cool oil from 150°C to 50°C. The rate of flow of oil is 2,500 kg/hr. The average specific heat of the oil is 2.5 kJ/kg K. The water enters the heat exchanger at 21°C. Determine :

Change in entropy during heat exchange process. [6]

UNIT II

3. (*a*) Prove that the law for expansion for a reversible adiabatic process in $PV^{\gamma} = C$. [6]

(*b*) In an engine working on a diesel cycle, inlet pressure and temperature are 1 bar and 17°C respectively. Pressure at the end of adiabatic compression is 35 bar. The ratio of expansion is 5. Calculate :

(*i*) Heat addition

(*ii*) Heat rejection

(*iii*) Efficiency of the cycle.

Take $\gamma = 1.4$, $C_p = 1.004$ kJ/kgK, $C_v = 0.717$ kJ/kgK [8]

(*c*) Define the following terms :

(*i*) Mean effective pressure

(*ii*) Work ratio. [4]

Or

4. (*a*) Compare Otto cycle and diesel cycle for the same compression ratio and same heat input. [4]

(*b*) 10 kg of compressed air at a pressure of 40 bar and temperature of 500°C receives heat at constant pressure until the temperature reaches to 1250°C. It is then expanded to 6 times of its volume which it had at the end of heat addition, the law of expansion being $PV^{1.3} = C$. Calculate the change in internal energy, work done and heat transfer in each process. Take $C_p = 1.0045$ kJ/kgK, $C_v = 0.7175$ kJ/kgK for air. [8]

(*c*) Determine air standard efficiency of air standard Otto cycle, when the cycle develops maximum work with the temperature limits of 300 K and 1200 K and working fluid is air. By keeping the same compression ratio, what will be the percentage change in efficiency if helium is used as working fluid ?

Take C_p = 5.22 kJ/kgK, C_v = 3.13 kJ/kgK for helium. [6]

UNIT III

5. (*a*) In a test to find dryness fraction of steam with a combined separating and throttling calorimeter, the following observations were recorded :

Water collected in the separating calorimeter = 4.5 kg

Steam condensed after throttling calorimeter = 45.5 kg

Inlet pressure of steam = 12.5 bar absolute

Temperature of steam after throttling = 145°C

Manometer reading = 97 mm of Hg

Barometer reading = 750 mm of Hg

Estimate the dryness fraction of steam as it enters the throttling calorimeter and dryness fraction of steam before separating calorimeter.

Take C_p for superheated steam = 2.1 kJ/kgK. [10]

(*b*) Explain the process of formation of steam using T-H and P-V diagram. [6]

Or

6. (*a*) Define the following terms :

(*i*) Latent heat of vaporization

(*ii*) Dryness fraction

(*iii*) Saturation temperature. [6]

(*b*) A Rankine cycle operates between pressures of 35 bar and 0.3 bar. The steam at entry of the turbine is dry saturated. Determine :

(*i*) Pump work

(*ii*) Turbine work

(*iii*) Rankine efficiency

(*iv*) Dryness at the end of expansion.

Assume flow rate of 12 kg/s. [10]

SECTION II

UNIT IV

7. (*a*) Explain clearly how the actual indicator diagram for a single stage compressor is different from the theoretical indicator diagram. [4]

(*b*) Write a short note on F.A.D. of a reciprocating compressor. [4]

(*c*) A single stage, double acting air compressor running at 300 rpm, required to deliver 10 m^3/min of air. The suction is at 1 bar and 27°C. The temperature at the end of compression is 180°C. The law of compression and expansion is $PV^{1.3} = C$ and the clearance volume ratio is 0.05. Determine the volumetric efficiency, the cylinder dimensions and the indicated power assuming that stroke is 1.25 times the cylinder diameter. [10]

Or

8. (*a*) Derive the expression for optimum value of the intercooler pressure in a two stage compressor. Also write the expression for pressure ratio in x stage compression by assuming perfect intercooling. [8]

(*b*) A three stage reciprocating air compressor compresses air from 1 bar and 20°C to 45 bar. The law of compression is $PV^{1.35} = C$ for all stages. Assume perfect intercooling and neglecting clearance, find minimum work required to compress 20 m^3/min of free air, also find intermediate pressures. [10]

UNIT V

9. (*a*) Explain the procedure to measure calorific value gaseous fuel experimentally. [6]

(*b*) A sample of 1 kg of coal has the following composition : Carbon = 78%, Hydrogen = 5%, Oxygen = 8%, Sulpher = 2%, Nitrogen = 2%, Ash = 5%. It is burnt in a furnace with 30% excess air. The flue gases enter the chimney at 335°C and atmosphere is at 15°C. Calculate the total mass of flue gases and quantity of heat carried away by them in kJ/kg of coal. Take C_p for Oxygen and Nitrogen = 1.005 kJ/kgK and C_p for CO_2 and SO_2 = 1.07 kJ/kgK. [10]

Or

10. (*a*) Define the following :

(*i*) Stoichiometric air

(*ii*) HCV and LCV of the fuel

(*iii*) Mixture strength. [6]

(*b*) A petrol engine uses fuel (C_7H_{16}), the measurement of fuel and air shows air fuel ratio as 17 : 1. Calculate Stoichiometric air-fuel ratio, mixture strength and volumetric analysis of products of combustion. [10]

UNIT VI

11. (*a*) Write a short note on classification of boilers. [4]

(*b*) What is IBR ? Explain some of its provisions. [4]

(*c*) The following observations were made during a boiler trial :

Coal used = 250 kg of calorific value = 29800 kJ/kg

Water evaporated = 2000 kg

Steam pressure = 11.5 bar (Abs)

Dryness fraction of steam = 0.95

Feed water temperature = 34°C

Find :

(*i*) Equivalent evaporation

(*ii*) Efficiency of the boiler. [8]

Or

12. (*a*) Explain the following terms :

(*i*) Exergy

(*ii*) Irreversibility. [6]

(*b*) Air enters an air turbine at a pressure of 6 bar and 327°C with a velocity of 100 m/s and leaves it at 1 bar, 177°C and at 60 m/s. Flow is adiabatic and surrounding temperature is 300 K. Find :

(*i*) Actual work and irreversible work per kg of air flow.

(*ii*) Irreversibility and effectiveness of the system per kg of air flow.

Assume C_p = 1 kJ/kgK, C_v = 0.71 kJ/kgK and steady flow conditions. [10]