Code : 021407

B.Tech 4th Semester Exam., 2014

THERMODYNAMICS

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.*

(v) Use of Steam table, Mollier chart and Psychrometric charts is allowed.

1. Answer any *seven* of the following (each answer should be accommodated within 5 to 7 lines) : 2×7=14

(a) Define thermodynamic system and give its classification.

(b) Explain the difference between energy interaction as 'heat' and 'work', and give their common characteristics.

(c) Showing the direction of heat flow, distinguish between a 'heat engine' and a 'heat pump'.

(d) Is the value of integral $\int_1^2 \frac{dtQ}{T}$ same for all the processes between state 1 and state 2? Explain.

(e) Two heat engines *A* and *B* have the same thermal efficiency of 30%. The sink temperature for both of them is 300 K, whereas the source temperature for *A* is 600 K and for *B* it is 1000 K. Which one is performing better?

(f) Why do constant temperature lines on Mollier diagram become parallel to abscissa in the superheated region at low pressure?

(g) From the relationships given below, identify the relation which is consequence of Gibbs' function :

(i) $du = Tds - pdv$

(ii) $dg = -sdT + vdp$

(iii) $dh = Tds + vdp$

(iv) $da = -sdT - pdv$

(h) Give five important assumptions for air standard cycle in case of IC engines.

(i) Give the effect of lowering the condenser pressure in case of a simple Rankine cycle on turbine work output, cycle efficiency and pump work input.

(j) When are the adiabatic saturation and wet-bulb temperatures equivalent for atmospheric air?

2. (a) State and explain the first law of thermodynamics. 4

(b) Two air flows are combined to a single flow. The inlet pressure for the stream is 100 kPa. The flow rate for one is 1 m^3/s at 293 K, while for the other it is 2 m^3/s at 473 K. The mixing takes place in a horizontal mixture without any heat transfer. Neglecting kinetic energy, find the volume flow rate and temperature of air at exit pressure of 100 kPa. 10

3. (a) Prove that entropy of a closed system, which is thermally insulated from the surroundings, either increases or remains constant if the process is reversible. 6

(b) 1 kg of air expanded reversibly in a cylinder behind a piston isothermally maintaining the temperature at 530 K till the volume gets doubled. The piston is then pushed back at constant pressure till the original volume is

restored. Sketch the processes on *T-S* plane having constant temperature and constant pressure lines also. Calculate the change in entropy and heat flow for each process and overall. 8

4. (a) What do you understand by a reversible process? Distinguish among internally, externally and totally reversible processes. Whether the process has to be quasistatic? Justify. 4

(b) A Carnot engine, with air as working fluid, operates between maximum and minimum pressures of 6·25 MPa and 0·104 MPa. The limiting temperatures being 580 K and 290 K, find (i) thermal efficiency, and (ii) work ratio for the cycle. Sketch the cycle on *p-v* and *T-S* planes. 10

5. (a) Define the following : 4

(i) Saturation pressure

(ii) Saturation temperature

(iii) Degree of superheat

(iv) Liquid-vapour saturation curve

(b) A closed system consists of 1 kg of steam. This system undergoes three different reversible processes to constitute a thermodynamic cycle. The initial condition of steam pressure is 10 bar and $x = 0{\cdot}40$. The process 1–2 is constant volume heating till pressure becomes 35 bar. The process 2–3 is isothermal expansion up to pressure of 10 bar. The process 3–1 is constant pressure cooling to bring the system back to its initial state. Sketch the cycle on Mollier diagram. For each process, calculate (i) entropy change, (ii) heat transfer, and (iii) work done. Also find cycle efficiency. 10

6. (a) Identify ideal cycle for spark-ignition reciprocating engine and name the process involved in it. Also find the expression for its cycle efficiency. 6

(b) A diesel engine has a compression ratio of 20 : 1. The pressure, temperature and volume at the beginning of the compression are 95 kPa, 290 K and 0·50 litre respectively. The maximum cycle temperature is 1800 K. Find the cycle efficiency and maximum pressure. 8

7. (a) Why is Carnot cycle not a realistic model for steam power plant? Name the cycle suitable for steam power plant and plot the same on T-S diagram. 4

(b) In a reheat cycle, the initial steam pressure and maximum temperature are 150 bar and 550 °C respectively. If the condenser pressure is 0·1 bar and moisture at condenser inlet is 5%, find (i) reheat pressure, (ii) cycle efficiency, and (iii) steam flow rate in kg/kW-h assuming ideal processes. Neglect pump work. 10

8. (a) Define 'mole fraction' and 'mass fraction' in a mixture of nonreacting ideal gases and establish a relationship between them for a mixture of two gases. 7

(b) A mixture of ideal gases at a pressure of 150 kPa and 40 °C contains 8 kg of nitrogen and 5 kg of oxygen. Determine for the mixture (i) average molecular weight, (ii) specific gas constant, and (iii) the two specific heats. C_v and C_p for nitrogen may be taken as 0·70 kJ/kg-K and 1·037 kJ/kg-K, whereas for oxygen it is 0·75 kJ/kg-K and 1·04 kJ/kg-K. 7

9. *(a)* Define absolute humidity and relative humidity, and establish a relation between them.

(b) Consider 100 m^3 of atmospheric air which is an air-water vapour mixture at 100 kPa and 40 °C having a relative humidity of 40%. Find the *(i)* mass of dry air, *(ii)* mass of vapour, *(iii)* specific humidity, and *(iv)* dew point. Also calculate the amount of water condensed if the mixture is cooled to 10 °C. 14

★ ★ ★