Code : 021407

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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.*

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

(a) In case of free expansion between state-1 and state-2, which of the following is correct considering no heat interaction?

(i) $U_1 = U_2$

(ii) $W_{1-2} = 0$

(iii) $Q_{1-2} = 0$

(iv) All of the above

(b) The latent heat of vaporisation with increase in pressure of water

(i) increases

(ii) remains constant

(iii) decreases

(iv) None of the above

(c) As differentials heat and work would be described mathematically as

(i) inexact

(ii) exact

(iii) discontinuity

(iv) point function

(d) Heat is being supplied to air in a cylinder fitted with a frictionless piston held by a constant weight, the process is

(i) isochoric

(ii) isobaric

(iii) adiabatic

(iv) isothermal

(e) Expansion of hot gases in an IC engine can be approximated to an

(i) isochoric

(ii) isobaric

(iii) adiabatic

(iv) isothermal

(f) A refrigerator and a heat pump operate between same temperature limits. If the COP of refrigerator is 4, then the COP of heat pump is

(i) 3

(ii) 4

(iii) 4·4

(iv) 5

(g) A relation of vapour pressure to enthalpy of vaporisation is expressed in

(i) van der Waals equation

(ii) Maxwell relation

(iii) Carrier equation

(iv) Clausius-Clapeyron equation

(h) For same maximum pressure and temperature among Otto, diesel and dual cycles

(i) diesel cycle is most efficient

(ii) Otto cycle is most efficient

(iii) dual cycle is most efficient

(iv) None of the above

(i) Thermal efficiency of Rankine cycle can be improved by steam

(i) reheating

(ii) superheating

(iii) regeneration

(iv) None of the above

(j) The process of removing moisture from air at constant dry-bulb temperature is known as

(i) sensible heating

(ii) sensible cooling

(iii) dehumidification

(iv) humidification

2. (a) Define internal energy. Show that internal energy is a property of a system. 6

(b) A cylinder contains $0 \cdot 12 \text{ m}^3$ of air at 1 bar and 90 °C. It is compressed to $0 \cdot 03 \text{ m}^3$. The final pressure being 6 bar. Find the index of compression, increase in internal energy and heat transferred. Take $R = 0 \cdot 287$ kJ/kg-K and $C_v = 0 \cdot 717$ kJ/kg-K. 8

3. (a) Prove that the Kelvin-Planck and Clausius statement of the second law of thermodynamics are equivalent to each other. 6

(b) A reversed Carnot cycle operating as a refrigerator has a refrigerating capacity of 100 kJ/s while operating between temperature limits of −20 °C and 35 °C. Determine (i) power input and (ii) COP. What would be its efficiency if it runs as an engine? 8

4. (a) State and prove Clausius inequality. 7

(b) During isothermal heat addition process of a Carnot cycle, 800 kJ heat is added to the working fluid from a source of 527 °C. Determine (i) change in entropy of the working fluid, (ii) change in entropy of the source and (iii) total entropy change during the process. 7

5. (a) Define the following : 6

   (i) Pure substance

   (ii) Saturation state

   (iii) Triple point and critical point

   (b) A vessel of volume $0 \cdot 04$ m^3 contains a mixture of saturated water and saturated steam at a temperature of 250 °C. The mass of liquid is 9 kg. Find the pressure, the mass, the specific volume, the enthalpy, the entropy and the internal energy. 8

6. In an air-standard dual cycle, the pressure and temperature at beginning of compression are 1 bar and 57 °C respectively. The heat supplied in the cycle is 1250 kJ/kg, two-third of this being added at constant volume and rest at constant pressure. If the compression ratio is 16, determine the air-standard efficiency. 14

7. (a) Give limitation of Carnot vapour power cycle and explain how Rankine cycle helps in overcoming them. 5

   (b) A steam power plant running on Rankine cycle has steam entering HP turbine at 20 MPa, 500 °C and leaving LP turbine at 90% dryness. Considering condenser pressure of 0·005 MPa and reheating occurring up to the temperature of 500 °C, determine the thermal efficiency of the cycle. 9

8. (a) What do you understand by dry-bulb and wet-bulb temperatures? When do d.b.t., w.b.t. and d.p.t. become equal? 6

   (b) 10 m^3/min of air at 1 atm and 20 °C with 90% RH is mixed with 20 m^3/min of air at 1 atm and 40 °C with 20% RH. Calculate the resulting state of mixture. 8

9. (a) Explain Maxwell relation in thermodynamics. 6

   (b) A gaseous mixture consists of 1 kg of oxygen and 2 kg of nitrogen at a pressure of 150 kPa and a temperature of 20 °C. Determine the change in internal energy and enthalpy of the mixture when the mixture is heated to a temperature of 100 °C (i) at constant volume and (ii) at constant pressure. 8

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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'.

(*Turn Over*)

(d) Is the value of integral $\int_1^2 \frac{dt\,Q}{T}$ 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.

(*Continued*)

(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

(Turn Over)

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

(Continued)

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

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Code : 021407

B.Tech. 4th Semester Exam., 2015

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. Write True or False of the following (any *seven*) : $2\times7=14$

(a) Volume is the extensive property of a thermodynamic system.

(b) A closed system is one in which neither mass nor energy cross the boundary of the system.

(c) If the reversible process takes place at constant pressure, change in enthalpy in a closed system is equal to the heat transfer.

(d) A real gas obeys perfect gas law at very high temperature and low pressure.

(e) The entropy of universe tends to zero.

(f) The Clausius-Clapeyron equation gives the slope of a curve in p-T diagram.

(g) The state of a wet vapour cannot be specified only by pressure and dryness fraction.

(h) When DBT, WBT and DPT are identical, it means that the air is saturated.

(i) In a Rankine cycle heat is rejected reversibly at constant volume.

(j) A gas turbine works on Brayton cycle.

2. *(a)* State and explain zeroth law of thermodynamics. 4

(b) One kg of air at 1 bar and 300 K is compressed adiabatically till its pressure becomes 5 times the original pressure. Then it is expanded at constant pressure and finally cooled at constant volume to return to its original state. Calculate heat transfer, work transfer and change in internal energy for each process and for the cycle. 10

3. Air at 288 K passes through a heat exchanger at a velocity of 30 m/s where its temperature is raised to 1073 K. It then enters a turbine with the same velocity of 30 m/s and expands until the temperature falls to 923 K. On leaving the turbine, air is taken at a velocity of 60 m/s to a nozzle where it expands until the temperature has fallen to 773 K. Calculate for the air flow rate of 2 kg/s—*(a)* the rate of heat transfer to the air in the heat exchanger; *(b)* the power output from the turbine assuming no heat loss and *(c)* the velocity at exit from the nozzle assuming no heat loss. 14

4. *(a)* Show that the COP of a heat pump is greater than the COP of a refrigerator by unity. 4

   (b) A heat engine working on Carnot cycle exchanges heat from three reservoirs at 200 K, 300 K and 400 K. If it draws 5 MJ from the 400 K reservoir and does 840 kJ of work during a cycle of operation, find the amount and direction of heat interaction with other reservoirs. 10

5. *(a)* An inventor claims to have designed an engine which receives 2·5 kJ of heat and produces 0·625 kJ of useful work between source at 60 °C and sink at 263 K. Is this claim valid? 7

   (b) m kg of air at T_1 is adiabatically mixed with same mass of air at T_2 in a container. Find the change of entropy and prove that this change is always positive. 7

6. *(a)* Derive the expression of thermal efficiency of diesel cycle. 9

   (b) With the help of p-v and T-s diagrams, show that for the same maximum pressure and temperature of the cycle $\eta_{Diesel} > \eta_{Otto}$. 5

7. A vessel of volume 0·04 m^3 contains a mixture of saturated water and saturated steam at a temperature of 250 °C. The mass of the liquid present is 9 kg. Find the pressure, mass, specific volume, enthalpy, entropy and internal energy. 14

8. Steam at 20 bar, 360 °C is expanded in a steam turbine plant to 0·08 bar. If the plant works on Rankine cycle, find network and cycle efficiency.

   If the turbine and pump have each 80% efficiency, find the percentage change in network cycle efficiency. 14

9. 120 m^3/min of air at 35 °C DBT and 45% RH is adiabatically mixed with 325 m^3/min of air at 20 °C DBT and 10 °C DPT. Determine the specific humidity, DBT, and DPT of the mixture without using psychrometric chart. 14

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