(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

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*) : 2×7=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.

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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CIVIL

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

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2012

THERMODYNAMICS

Time : 3 hours | *Full Marks* : 70

Instructions :

(i) All questions carry equal marks.

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

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

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

(v) Use of Tables and Charts is permitted.

1. Write True or False from any *seven* of the following :

   (a) The first law of thermodynamics states that heat cannot flow from lower temperature to higher temperature without the aid of an external agency.

   (b) The displacement work is equal to $\int PdV$.

   (c) Otto cycle consists of two constant volumes and two adiabatic processes.

(d) For same maximum pressure and heat input the thermal efficiency of otto cycle is more than that of diesel cycle.

(e) Gases have two specific heats.

(f) A process will be reversible if it involves friction.

(g) The efficiency of a Carnot engine depends on the temperatures of source and sink.

(h) When a vapour condenses into a liquid its temperature remains constant.

(i) For saturated air WBT is more than DPT.

(j) On psychrometric chart DPT lines are vertical.

2. *(a)* Derive an expression of displacement work for the following quasistatic processes :
   (i) Isothermal process
   (ii) Polytropic process

(b) Distinguish between the following :
   (i) Closed and Open system
   (ii) Intensive and Extensive property
   (iii) Point and Path function

3. Air at a temperature of 15 °C passes through a heat exchanger at a velocity of 32 m/s, where its temperature is raised to 810 °C. It then enters a turbine with the same velocity of 32 m/s and expands until the temperature falls to 640 °C. On leaving the turbine the air is taken at a velocity of 60 m/s to a nozzle where it expands until the temperature has fallen to 500 °C. If the air flow rate is 2 kg/s, calculate the—

   (a) rate of heat transfer to the air in the heat exchanger;

   (b) power output from the turbine assuming no heat loss;

   (c) velocity at exit from the nozzle assuming no heat loss.

4. *(a)* State and explain both the statements of second law of thermodynamics and prove that they are equivalent.

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

   (c) What is PMMZ?

5. A perfect gas of molecular weight 29·79 occupies a volume of 0·3 m^3 at 8 bar and 270 °C. The gas is allowed to expand against a piston in the cylinder till 1 bar in the following manners :

   (a) Hyperbolically

   (b) Adiabatically ($\gamma = 1 \cdot 39$)

   (c) Polytropically ($n = 1 \cdot 25$)

   What will be the amount of heat transfer and change in entropy during expansion?
   Represent the above processes on *P-V* and *T-S* planes.

6. *(a)* Why do the isobars on Mollier diagram diverge from one another?

   (b) A steam boiler initially contains 5 m^3 of steam and 5 m^3 of water at 1 MPa. Steam is taken out at constant pressure until 4 m^3 of water is left. What is the heat transferred during the process?

7. *(a)* Why is Carnot cycle not practicable for a steam power plant?

   (b) A heat engine working on the Rankine cycle uses steam at 20 bar dry saturated. The condenser vacuum is 540 mm of mercury. Barometer reading is 760 mm of mercury. Find Rankine cycle efficiency and work ratio.

(Continued)

8. *(a)* How does the thermal efficiency of an air standard diesel cycle vary with compression and cut-off ratio?

   (b) A diesel cycle has compression ratio 14 and heat supply up to 5% of the stroke: Calculate the air standard efficiency of the cycle. If the compression ratio is increased from 14 to 19 and the cut-off is adjusted to give the same air standard efficiency obtained above, find the required change in the cut-off.

9. *(a)* What do you understand by DBT, WBT, DPT, relative humidity and humidity ratio?

   (b) What is the difference between WBT and thermodynamic WBT?

   (c) Represent the following processes on psychrometric chart :

   (i) Sensible cooling and heating

   (ii) Humidification and dehumidification

   (iii) Adiabatic saturation

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Code : 021307

B.Tech. 3rd Semester Exam., 2013

THERMODYNAMICS

Time : 3 hours *Full Marks* : 70

Instructions :

(i) All questions carry equal marks.

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

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

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

(v) Use of Tables and Charts permitted.

1. State whether the following statements are True or False (any *seven*) :

(a) The sum of internal energy and pressure volume product is called enthalpy.

(b) Diesel cycle consists of two constant volumes and two adiabatic processes.

(c) For the same compression ratio and same heat input the thermal efficiency of Otto cycle is less than that of Diesel cycle.

(d) Intensive properties are independent of the mass of the system.

(e) An isolated system is one which permits the passage of energy only.

(f) Liquids have two specific heats.

(g) Thermal power plant works on Rankine cycle.

(h) Sublimation is the process of changing from solid state to direct gas state.

(i) On psychrometric chart, DBT lines are horizontal.

(j) During sensible cooling process, specific humidity decreases.

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

(b) Derive an expression of displacement work for an adiabatic process.

(c) What do you mean by flow work?

3. *(a)* Show that the efficiency of all reversible heat engines operating between the same temperature levels is the same.

(b) What is a Carnot cycle? Derive its efficiency with the help of p-V diagram and block diagram.

4. 2 kg of ice at –6 °C is exposed to the atmosphere which is at 25 °C. The ice melts and comes into thermal equilibrium with the atmosphere. Determine—

   (a) the entropy increase of the universe;

   (b) the minimum amount of work necessary to convert the water back into ice at –6 °C.

5. (a) What do you mean by triple point?

   (b) A large insulated vessel is divided into two compartments, one containing 5 kg of dry saturated steam at 2 bar and the other 10 kg of steam, 0·8 dry at 5 bar. If the partition is removed and the steam is mixed thoroughly and allowed to settle, find the final pressure, steam quality and entropy change.

6. (a) What is the reversible cycle that represents the simple steam power plant? Draw the flow, p-V, T-S and h-S diagrams of this cycle.

   (b) What do you understand by the mean temperature of heat addition?

   (c) How are the maximum temperature and maximum pressure in the Rankine cycle fixed?

7. (a) Develop an expression for the thermal efficiency of an air-standard Diesel cycle.

   (b) Compare the efficiency of Otto, Diesel and dual cycles in the following cases with the help of p-V and T-S diagrams :

   (i) For the same compression ratio

   (ii) For the same maximum pressure and temperature

8. 3 kg of air at 40 °C DBT and 20 °C WBT is adiabatically mixed with 2 kg of air at 25 °C DBT and 10 °C DPT. Determine the final specific humidity and temperature of the mixture without using psychrometric chart.

9. (a) A mixture of ideal gases consists of 2 kg of O_2 and 4 kg of CO_2 at a pressure of 3 bar and temperature of 25 °C. If the mixture is heated at constant pressure to 50 °C, find the change in entropy of the mixture.

   (b) Write the Maxwell's equations.

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Code : 021307

B.Tech. 3rd Semester Exam., 2014

THERMODYNAMICS

Time : 3 hours *Full Marks* : 70

Instructions :

(i) All questions carry equal marks.

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

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

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

(v) Use of Tables and Charts permitted.

1. State whether the following statements are True or False (any *seven*) :

(a) Zeroth law of the thermodynamics defines temperatures.

(b) Characteristic equation of gas is given by (v = specific volume, m = mass of gas) $pv = mRT$.

(c) Otto cycle consists of two constant volumes and two adiabatic processes.

(d) Internal energy of ideal gas is a function of temperature and volume.

(e) One of the *Tds* equations has the form

$$Tds = du - vdp$$

(f) The entropy of fixed amount of ideal gas increases in every isothermal compression.

(g) At tripple point, ice occupies maximum specific volume.

(h) The specific volume of water when heated from 0 °C, first increases then decreases.

(i) The relationship between $(COP)_{Heat\ pump}$ and $(COP)_{Refrigerator}$ for the same range of temperature operation is

$$(COP)_{HP} = (COP)_{R+1}$$

(j) Standard Barometric pressure is 1013·25 M bar.

2. What do you mean by closed system and open system? Explain.

3. *(a)* What do you mean by temperature? What are the common scales used for measuring the temperature of human body?

(b) What do you mean by thermodynamic equilibrium? What is equality of temperatures?

4. (a) 0·5 kg of a perfect gas is heated from 100 °C to 300 °C at a constant pressure of 2·8 bar. It is then cooled to 100 °C at constant volume. Find the overall change in entropy. Take $C_p = 1$ kJ/kg K, $C_v = 0{\cdot}72$ kJ/kg K.

   (b) An inventor claims to have heat engine which is capable of developing 19 kW while working between the temperature limits 30 °C and –40 °C. It receives only 1000 kJ/min of heat. Discuss the possibility of the claim.

5. What are Helmholtz function and Gibb's function?

6. (a) List the assumptions made in the analysis of air-standard cycle.

   (b) With the help of p-V and T-S diagrams show that for the same compression ratio and same heat input

$$\eta_{Otto} > \eta_{Dual} > \eta_{Diesel}$$

7. In a thermal power plant operating on an Ideal Rankine cycle, steam of 15 bar and 250 °C enters a turbine which generates 40 kW indicated power. If the steam consumption is 300 kg/hr and condenser is maintained at 0·15 bar, determine the final condition of steam, Rankine efficiency and relative efficiency. Neglect pump work. Also determine the fuel to be supplied/hr if its C_{vf} is 41850 kJ/kg.

  (Turn Over)

8. Define and explain the terms in relation to psychrometry.

   (a) Dry bulb, wet bulb and dew point temperature

   (b) Relative humidity and specific humidity

9. A mixture of 1 kg of oxygen and 2 kg of nitrogen occupies 1·2 m^3 volume of temperature 300 K. Assuming perfect gas behaviour, determine the following :

   (a) Specific volume

   (b) Pressure

   (c) Gas constant

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Code : 021307

B.Tech 3rd Semester Examination, 2016

Thermodynamics

Time : 3 hours *Full Marks : 70*

Instructions :

*(i) There are **Nine** Questions in this Paper*

*(ii) Attempt **Five** questions in all.*

*(iii) **Question No. 1 is Compulsory.***

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

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1. Multiple choice question (do any seven): 2×7=14

(i) The difference between the pressure of fluid and the pressure of atmosphere is called as

(a) Barometric pressure

(b) Absolute pressure

(c) Gauge Pressure

(d) None of these

(ii) Which of the following sets has all properties as point functions?

(a) Entropy, enthalpy, work

(b) Pressure, temperature, heat

(c) Heat, work, enthalpy

(d) Temperature, enthalpy, internal energy

(iii) Which of the following sets has all open systems?

(a) Boiler, gas turbine, compressor, condenser

(b) Pump, thermo-flask, refrigerator, petrol engine

(c) Window air conditioner, scooter engine, thermometer, diesel engine

(d) Jet engine, gas engine, pressure cooker, steam turbine

(iv) The elastic work (δW) per unit volume required fo stretching a wire of length is given by the expression

(a) $-\frac{\sigma}{d\varepsilon}$

(b) $-\sigma d\varepsilon$

(c) $-\sigma - d\varepsilon$

(d) None of the above

(v) The thermometric property of electrical resistanc thermometer is

(a) Current

(b) Potential difference

(c) Magnetic

(d) Resistance

(vi) The internal energy for a perfect gas is expressed as

(a) $\frac{\partial u}{\partial v} = c$

(b) $\frac{\partial u}{\partial v} = 0$

(c) $\frac{\partial u}{\partial v} < 0$

(d) $\frac{\partial u}{\partial v} > 0$

(vii) The following amount of heat transfer occurs during a cycle comprising of four processes.

120 kJ, –20kJ, 16 kJ, and 24 kJ

(a) 100 kJ

(b) 120 kJ

(c) 130 kJ

(d) 140 kJ

(viii) The Van der waals equation of state for real gases may by given by

(a) $p = \frac{RT}{v+b} + \frac{a}{v^2}$

(b) $p = \frac{RT}{v-b} - \frac{a}{v^2}$

(c) $p = \frac{RT}{v^2} + \frac{a}{v^2}$

(d) $p = \frac{RT}{v+b} - \frac{a}{v^2}$

(ix) Select the correct relation

(a) Tds=dU+pdV

(b) dH=Tds+Vdp

(c) Tds=$C_p$dt–Vdp

(d) All of these

2. (a) Describe Thermodynamic Equilibrium and Quasi-stati process. 4+4

(b) An air standard dual cycle has a compression ratio of 16 and compression begins at 1 bar, 50°C. The maximun pressure is 70 bar. The heat transferred to air at constan pressure is equal to that at constant volume. Estimate (a) the pressure and temperatures at the cardinal points of the cycle, (b) the cycle efficiency (Given: for air $\gamma = 1.4$, $C_v = 0.718$ kJ/kg K, and $C_p = 1.005$ kJ/kg K). 6

3. (a) What are the four processes which constitute the Carnot cycle. A Carnot cycle operates between 0°C and 100°C. Determine thermal efficiency, if it operates as a heat engine and COPs if it operates as Heat pump and Refrigerator. 5

(b) Describe Rankine Cycle? Define quality and dryness fraction of steam. 5+4

4. (a) Describe and Diesel Cycle. 5

(b) A steam power plant operates on a simple ideal Rankine cycle between the pressure limits of 25 bar and 0.10 bar and handles 2 kg of steam. The temperature of steam at turbine inlet is 360°C. The steam enters a condenser and after condensation, the pump feeds back the steam into boiler. Show (a) p-v diagram with saturation lines; (b) T-S diagram with saturation lines; and calculate (c) the thermal efficiency of the cycle, (d) the net power output of the power plant, (e) the work ratio. 9

5. (a) Show the equivalence between statements of Kelvin-Planck and Clausius for 2nd law of thermodynamics. 5

(b) Derive the Inequality of Calusius as an criterion of reversibility of irreversibility of a thermodynamic cycle. 9

6. (a) Draw p-v diagram for polytropic process pv^n=constant, for n=0, n=1, n=2 & n=∞ under expansion and compression processes. 5

(b) 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, the mass, the specific volume, the enthalpy, the entropy and the internal energy. Use the Steam Table. 9

7. (a) Describe Available and Unavailable energy. 5

(b) What are Helmholtz's and Gibb's functions. Write four Maxwell's Equations. 5+4

8. (a) Derive equation of efficiency for ideal Otto Cycle i.e. $\eta_{otto} = 1 - \frac{1}{r_k^{\gamma-1}}$ In an ideal Otto cycle, the air at the beginning of isentropic compression is at 1 bar and 15°C. The ratio of compression is 8. If the heat added during the constant volume process is 1000 kJ/kg then determine (i) the air standard efficiency; (ii) work done; (iii) heat rejected; (iv) maximum temperature of air during the cycle. 5+4

(b) A reversible heat engine operates between two reservoirs at temperatures of 600°C. The engine drives a reversible refrigerator which operates between reservoirs at temperatures of 40°C and –20°C. The heat transfer to the heat engine is 2000 kJ and the net work output of the combined engine refrigerator plant is 360 kJ.

(a) Evaluate the heat transfer to the refrigerant and the net heat transfer to the reservoir at 40°C.

(b) Reconsider (a) given that the efficiency of the heat engine and the COP of the refrigerator are each 40% of their maximum possible values. 5

9. (a) Using the steady flow energy equation, find the work done in Turbine and compressor. 5

(b) Derive a steady state energy flow equation for any thermodynamic system operating under control volume and control surface. 9

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Code : 021307

B.Tech 3rd Semester Exam., 2017

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 option (any *seven*) : 2×7=14

(a) In a free expansion process involving ideal gas

(i) p = constant

(ii) v = constant

(iii) u = constant

(iv) w = constant

(b) The efficiency of a Carnot engine is given as 0·75. If the cycle direction is reversed, what will be the value of COP of the Carnot refrigerator?

(i) 0·271

(ii) 0·33

(iii) 1·27

(iv) 2·3

(c) The first law of thermodynamics gives $dU = \delta Q - \delta W$ and second law tells that $dS > \frac{\delta Q}{T}$. In which of the way these two laws can be combined and written?

(i) $dU \geq TdS - pdV$

(ii) $dU \leq dS - pdV$

(iii) $dU \leq TdS + pdV$

(iv) $dU = TdS - pdV$

(d) With increase in pressure, the latent heat of steam

(i) decreases

(ii) increases

(iii) remains the same

(iv) behaves unpredictably

(e) During dryness fraction measurement of steam using throttling calorimeter, the wet state of steam is throttled so as to lie in

(i) wet state

(ii) dry and saturated state

(iii) superheated state

(iv) supersaturated state

(f) Air standard efficiency of Diesel cycle is a function of

(i) compression ratio and cut-off ratio

(ii) compression ratio and ratio of maximum to minimum temperature

(iii) compression ratio and ratio of maximum to minimum pressure

(iv) compression ratio and ratio of exhaust temperature to inlet temperature

(g) The thermal efficiency of power plant lies in the range of

(i) 20% to 30%

(ii) 30% to 40%

(iii) 40% to 50%

(iv) 50% to 60%

(h) Select the correct order for flue gas flow in a steam power plant layout.

(i) Economiser, superheater and air-preheater

(ii) Air-preheater, economiser and superheater

(iii) Economiser, air-preheater and superheater

(iv) Superheater, economiser and air-preheater

(i) Humidity ratio can be expressed in terms of partial pressure of dry air (p_a) and water vapour (p_v) as

(i) $0 \cdot 622\left(\frac{p_a}{p_v}\right)$

(ii) $0 \cdot 622\left(\frac{p_v}{p_a}\right)$

(iii) $0 \cdot 622\left(\frac{p_v}{p_v - p_a}\right)$

(iv) $0 \cdot 622\left(\frac{p_v - p_a}{p_v}\right)$

2. *(a)* Derive the work done in process pv^{γ} = constant. 5

(b) A mass of 8 kg gas expands within a flexible container so that the p-v relationship is of the form pv^{γ} = constant. The initial pressure is 1000 kPa and the initial volume is 1 m^3. The final pressure is 5 kPa. If specific internal energy of the gas decreases by 40 kJ/kg, then find the heat transfer in magnitude and direction. 9

3. *(a)* Describe indicator thermal efficiency and brake thermal efficiency. 5

(b) A closed cylinder of 0·25 m diameter is fitted with a light frictionless piston. The piston is retained in position by a catch in the cylinder wall and volume on one side of the piston contains air at a pressure of 750 kN/m^2. The volume on the other side of the piston is evacuated. A helical spring is mounted coaxially with the cylinder in this evacuated space to give a force of 120 N on the piston in this position. The catch is released and the piston travels along the cylinder until it comes to rest after a stroke of 1·2 m. The piston is then held in its position of maximum travel

by a ratchet mechanism. The spring force increases linearly with the piston displacement to a final value of 5 kN. Calculate the work done by the compressed air on the piston. 9

4. *(a)* Describe a dual cycle. 5

(b) An air-standard Diesel cycle, the compression ratio is 16, and at the beginning of isentropic compression, the temperature is 15 °C and the pressure is 0·1 MPa. Heat is added until the temperature at the end of the constant pressure process is 1480 °C. Calculate *(i)* the cut-off ratio, *(ii)* the heat supplied per kg of air, *(iii)* the cycle efficiency and *(iv)* the mean effective pressure. 9

5. *(a)* Compare the Otto, Diesel and Dual cycle for same compression ratio. 5

(b) In a steam power plant, the condition of steam at inlet to steam generator is 20 bar and 300 °C and the condenser pressure is 0·1 bar. Two feed water heaters operate at optimum temperatures. Determine the *(i)* quality of steam at turbine exhaust, *(ii)* net work per kg, *(iii)* cycle efficiency and *(iv)* steam rate. Neglect pump work. 9

6. *(a)* Show that the decrease in available energy when heat is transferred through a finite temperature difference. 5

(b) Define heat pump and refrigeration plant, and discuss their working principles with coefficient of performances. 9

7. *(a)* Define irreversibility and describe various causes of irreversibility. 7

(b) A certain water heater operates under steady flow conditions receiving 4·2 kg/s of water at 75 °C temperature, enthalpy 313·93 kJ/kg. The water is heated by mixing with the steam which is supplied to the heater at temperature 100·2 °C and enthalpy 2676 kJ/kg. The mixture leaves the heater as liquid water at temperature 100 °C and enthalpy 419 kJ/kg. How much steam must be supplied to the heater per hour? 7

8. *(a)* Describe different modes of energy storage in a thermodynamic system. 5

(b) Describe the terms 'specific heat at constant volume', 'enthalpy' and 'specific heat at constant pressure'. 3×3=9

9. *(a)* 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, the mass, the specific volume, the enthalpy, the entropy and the internal energy. Use the steam table. 10

(b) Write four Maxwell's equations. 4

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