Total No. of printed pages = 7

19/3rd Sem/UME301

2021

BASIC THERMODYNAMICS

Full Marks – 100

Time – Three hours

The figures in the margin indicate full marks for the questions.

Answer *all* the questions. Use of steam tables are allowed.

1. Fill in the blanks (Any *four*) : 1×4=4

   (a) An isochoric process is a process during which the specific ____ remains constant.

   (b) A device that violates the 1stlaw of thermodynamics is called ____.

   (c) Factors that cause a process to be irreversible are called ____.

   (d) All three phases of a pure substance coexist in equilibrium at ____.

   (e) For petrol engine, compression ratio varies from ____ to ____.

[Turn over

2. Answer the following questions briefly (any *ten*) : $2 \times 10 = 20$

(a) Explain the terms 'Thermodynamic state' and 'Path of a Process'.

(b) What are the quasi-equilibrium and steady-flow processes ?

(c) Distinguish between the gage pressure and vacuum pressure.

(d) What are the 'Sensible energy' and 'Latent energy' ?

(e) Establish enthalpy is a function of temperature.

(f) Define the term 'quality of steam' ? What is the value of quality of a steam at saturated liquid ?

(g) What are the modes of heat transfer ? Define thermodynamic definition of work.

(h) What is a flow energy ? Write down the expression for total energy of a flowing fluid through a control volume.

(i) State Kelvin-Plank statements of Second law of thermodynamics. What is the main objective of a heat engine ?

(j) Which of the law of thermodynamics provides an absolute reference point for the determination of entropy ? State the law.

(k) What do you mean by displacement volume of an IC engine ? Define compression ratio of an IC engine.

(l) What is the function of a spark plug ? Define the term CC of an IC engine.

(m) Draw the P-v diagram of Diesel cycle and name the processes.

3. Explain briefly any *four* of the following : 4×5=20

(a) Enthalpy is a thermodynamics property.

(b) The property diagram (T-v) for phase change process of water.

(c) The working of a four stroke S.I. engine.

(d) Demonstration of Carnot cycle.

(e) Demonstration of Clausius inequality.

4. Solve any *four* of the following : 5×4=20

(a) A process changes from state 1 to state 2, where the pressure and volume are related by $PV^n = C$, where n and C are constants. Derive an expression for work done for this process.

(b) If a gas of volume 9000cm^3 and at pressure of 150kPa is compressed quasi-statically through a polytropic compression process with polytropic index, n = 1.3 until the volume becomes 3000cm^3, determine the final pressure and the work transfer.

(c) A constant pressure piston-cylinder contains 0.3 kg water as saturated vapor at 450 kPa. It is now cooled so the water occupies half the original volume. Find the work and heat transfer in the process. [Hint. Use steam table].

(d) Bananas are to be cooled from 24 to 13°C at a rate of 215 kg/h by a refrigeration system. The power input to the refrigerator is 1.4 kW. Determine the rate of cooling, in kJ/min, and the COP of the refrigerator. The specific heat of banana above freezing is 3.35 kJ/kg·°C.

(e) A Carnot refrigerator operates in a room in which the temperature is 25°C and consumes 2 kW of power when operating. If the food compartment of the refrigerator is to be maintained at 4°C, determine the rate of heat removal from the food compartment.

(f) A steam power plant operating in a Rankine cycle has saturated vapor at 3.0 MPa leaving the boiler. The turbine exhausts to the condenser operating at 10 kPa. Find the specific work done by the boiler feed pump and amount of heat transfer inboiler. [Hint Use steam table].

5. Solve any *three* of the following : 12×3=36

(a) A gas of mass 1.8 kg undergoes a quasi-static expansion which follows a relationship $P = a + bV$, where a and b are constants. The initial and final pressures are 1200 kPa and 300 kPa respectively and the corresponding volumes are 0.40 m^3 and 1.60m^3. The specific internal energy of the gas is given by the relation

$$u = 1.5\ Pv - 85\ kJ/kg.$$

Where Pis the kPa and v is in m^3/kg. Calculate the following :

(i) The net work done

(ii) The net heat transfer and

(iii) Maximum internal energy of the gas attained during expansion.

(b) Water contained in a piston-cylinder assembly undergoes two processes in series from an initial state where the pressure is 0.8 MPa and the temperature is 500°C.

Process 1–2: The water is cooled as it is compressed at a constant pressure of 0.8 MPa to the saturated vapor state.

Process 2–3: The water is cooled at constant volume to 160°C.

(i) For the overall process determine the work, in kJ/kg.

(ii) For the overall process determine the heat transfer, in kJ/kg.

[Hints. Initial state is at superheated region. Use steam table].

(c) A Carnot heat engine receives heat at 740 K and rejects the waste heat to the environment at 290 K. The entire work output of the heat engine is used to drive a Carnot refrigerator that removes heat from the cooled space at –16°C at a rate of 410 kJ/min and rejects it to the same environment at 290 K. Determine :

(i) The rate of heat supplied to the heat engine and

(ii) The total rate of heat rejection to the environment.

(d) Steam flows steadily through an adiabatic turbine. The inlet conditions of the steam are 4 MPa, 500°C, and 80 m/s, and the exit conditions are 30 kPa, 92 per cent quality, and 50 m/s. The mass flow rate of the steam is 12 kg/s. Determine :

(i) The change in kinetic energy,

(ii) The power output and

(iii) The turbine inlet area.

[Hint. Use steam table]

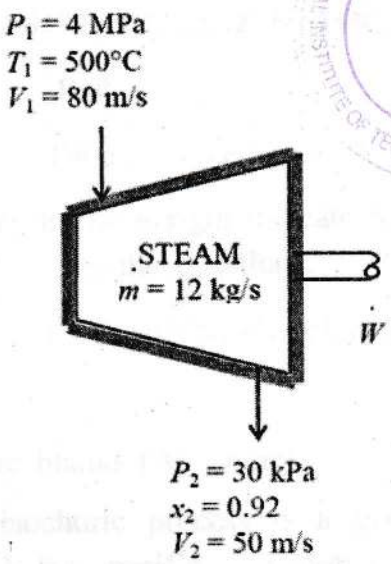

Fig. 5 (d)