Total number of printed pages–8

53 (ME 301) BTDM

2017

BASIC THERMODYNAMICS

Paper : ME 301

Full Marks : 100

Time : Three hours

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

Answer ***any five*** *questions.*

1. Answer ***any ten*** of the following : $2\times10=20$

(a) What do you mean by thermodynamics properties ? Distinguish between the intensive and extensive properties.

(b) What is specific gravity ? How is it related to density ?

(c) State thermodynamics definition of 'heat' and 'work'.

Contd.

(d) A refrigerator has a COP of 1·5. That is, the refrigerator removes 1·5 *kwh* of energy from the refrigerated space for each 1 *kwh* of electricity it consumes. Is this a violation of the first law of thermodynamics ? Explain.

(e) Write *any two* factors that cause a process to be irreversible. Why does a non-quasi-equilibrium compression process require a larger work input than the corresponding quasi-equilibrium one ?

(f) Define mass and volume flow rates. How are they related to each other ?

(g) Name the specific forms of energy associated with a "flowing fluid" and a "fluid at rest" through a control volume.

(h) What are the saturated and compressed liquids ?

(i) What is the difference between the critical point and the triple point ?

(j) Distinguish between the isobaric and isentropic processes.

(k) Define the term 'compression ratio' of an IC Engine. What is the use of spark plug in your bike ?

(l) Why is the engine of Maruti Swift car, known as IC Engine ? What is the function of 'clutch' in an IC Engine ?

2. Explain briefly ***any two*** of the following : 2×7=14

(a) The $(T\text{-}v)$ property diagram for phase change process of water.

(b) Working principle of 4-stroke SI Engine.

(c) The Carnot Cycle.

3. Answer ***any two*** of the following : 2×8=16

(a) What is a polytropic process ? Prove that the displacement-work in polytropic process is

$$ {}_1W_2 = \frac{1}{1-n}(P_2V_2 - P_1V_1) $$

And also show that

$$ {}_1W_2 = \frac{P_1V_1}{n-1}\left[1 - \left(\frac{P_2}{P_1}\right)^{\frac{n-1}{n}}\right] $$

where the symbols have their usual meaning.

(b) Demonstrate the following relation for a reversible cycle applying the concept of Carnot's principle,

$$\left(\frac{Q_H}{Q_L}\right)_{rev} = \frac{T_H}{T_L}$$

where, Q_H and T_L are the heat transfer between a reversible device and the high-and low-temperature reservoirs. T_H and T_L are the absolute temperatures of high-and low-temperature reservoirs respectively.

(c) Show that the thermal efficiency of a gasoline engine is

$$\eta_{th} = 1 - \frac{1}{r^{\gamma} - 1}$$

where, r = compression ratio

γ = specific heat ratio .

4. Answer ***any five*** of the following : 4×5=20

(a) Determine the total work done by a gas system during expansion process as shown in *Figure-1*.

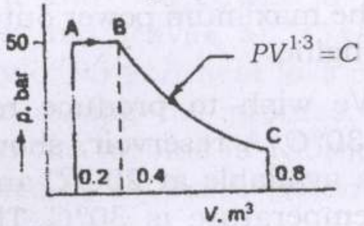

Figure -1

(b) A milk chilling unit can remove heat from the milk at the rate of 41·87 MJ/h. Heat leaks into the milk from the surroundings at an average rate of 4·187 MJ/h. Find the time required for cooling a batch of 500kg of milk from 45°C to 5°C. Take the C_p of milk to be 4·187 $kJ/kg.K$.

(c) A cylinder fitted with a piston has a volume 0·1 m^3 and contains 0·5kg of steam at 0·4MPa. Heat is transferred to the steam until the temperature is 300°C, while the pressure remains constant. Determine the heat transfer.

(d) A diffuser receives 0·1 kg/s steam at 500kPa, 350°C. The exit is at 1 MPa, 400°C with negligible kinetic energy and the flow is adiabatic. Find the diffuser inlet velocity and the inlet area.

(e) A heat engine operates between a source at 550°C and a sink at 25°C. If heat is supplied to the heat engine at a steady rate of 1200 kJ/min, determine the maximum power output of this heat engine.

(f) We wish to produce refregeration at –30°C. A reservoir, shown in Figure-2 is available at 200°C and the ambient temperature is 30°C. Thus, work can be done by a cyclic heat engine operating between the 200°C reservoir and the ambient. This work is used to drive the refrigerator. Determine the ratio of the heat transferred from 200°C reservoir to the heat transferred from –30°C reservoir, assuming all processes are reversible.

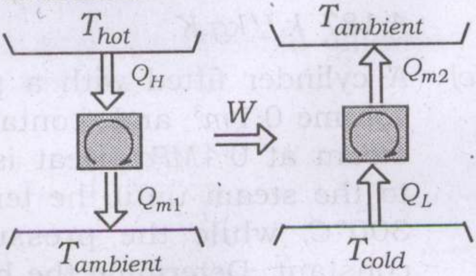

Figure-2

(g) A steam power plant has a steam generation exit at 4 MPa, 500°C and a condenser exit temperature of 45°C. Assume all components are ideal and find the specific work output of the turbine.

5. Answer ***any two*** of the following : $2\times15=30$

(a) Steam enters a turbine steadily at $10\,MPa$ and $550°C$ with a velocity of $60 m/s$ and leaves at $25 kPa$ with a quality of 95%. A heat loss of $30 kJ/kg$ occurs during the process. The inlet area of the turbine is $150 cm^2$, and the exit area is $1400 cm^2$. Determine—

(i) The mass flow rate of the steam

(ii) The exit velocity and

(iii) The power output.

(b) The Balagaon Thermal Power Station (BTPS) which produces $300 MW$ of electric power operates on a simple ideal Rankine cycle with turbine inlet conditions of $5 MPa$ and $450°C$ and a condenser pressure of $25 kPa$. The coal used in this plant has a heating value (energy released when the fuel is burned) of 29,300 kJ/kg. It is found that 75% of this energy is transferred to the steam in the boiler and the electric generator has an efficiency of 96%. Determine —

(i) The thermal efficiency of the cycle

(ii) The overall plant efficiency and

(iii) The required rate of coal supply.

(c) In S.I. engine working on the ideal Otto cycle has the compression ratio 6. The initial pressure and temperature of air are 1 *bar* and 37°*C*. respectively. The maximum pressure in the cycle is 30*bar*. For unit mass flow, calculate—

(i) The pressure, volume and temperatures at various salient points of the cycle.

(ii) The ratio of heat supplied to the heat rejected and

(iii) Air standard efficiency

Assume, ratio of the specific heats to be 1·4 for air,

$$n=\frac{1}{29},$$

$$R=8{\cdot}314\, kJ/kmol,$$

$$C_V=0{\cdot}717\, kJ/kg.K$$
