B.E. Fourth Semester (Mechanical / Power Engineering) (C.B.S.)

Engineering Thermodynamics

P. Pages : 3 | NKT/KS/17/7284/7308

Time : Three Hours | Max. Marks : 80

Notes :
1. All questions carry marks as indicated.
2. Solve Question 1 OR Questions No. 2.
3. Solve Question 3 OR Questions No. 4.
4. Solve Question 5 OR Questions No. 6.
5. Solve Question 7 OR Questions No. 8.
6. Solve Question 9 OR Questions No. 10.
7. Solve Question 11 OR Questions No. 12.
8. Assume suitable data whenever necessary.
9. Illustrate your answers whenever necessary with the help of neat sketches.
10. Use of non programmable calculator is permitted.
11. Use of steam table and Mollier chart is permitted.
12. The solutions must be supported with appropriate P-V/T-S/h-s diagrams.

1. a) Explain thermodynamic system and its types with suitable examples. **6**

b) In a particular non-flow system, a certain amount of working substance undergoes a frictionless process following the pressure - volume relation as P = [5/V+3], where P is in bar and V is in m^3. During the process volume changes from 0.12 m^3 to 0.04 m^3 and the system rejects 92 kJ of heat. Determine : **7**

i) Workdone

ii) Change in internal energy

iii) Change in enthalpy of system.

OR

2. a) Explain the Zeroth law of thermodynamics and gives its significance for temperature measurement. **4**

b) Explain the concept of thermodynamic equilibrium. **3**

c) Prove that the heat transfer (Q) during polytropic process is given by ; **6**

$$Q = \frac{(r-n)}{(r-1)} \times \text{workdone}$$

where r = Index of isentropic process, n = Index of polytropic process.

3. a) Explain the first law of thermodynamics for a closed system undergoing a cycle and change of state. **5**

b) An ideal gas of 20.6 bar, 0.142 m^3 and 337°C expands according to the law PV=constant to six times the initial volume. The gas is further cooled to 30°C according to the law V = constant. Finally compressed back to initial condition according to the law PV^{γ} =constant. Find the net workdone and heat transfer during the complete cycle. Show the cycle on PV and TS diagram Take $\gamma = 1.4$. **9**

OR

4.	a)	State the general steady flow energy equation and deduce its simplified form for ; i) Steam nozzle. ii) Boiler	**6**
	b)	In an air compressor, air flows steadily at the rate of 15 kg per min. The air enters the compressor at 5 m/sec with a pressure of 1 bar and specific volume of 0.5 m^3/kg. It leaves the compressor at 7.5 m/sec with a pressure of 7 bar and a specific volume of 0.15 m^3/kg The internal energy of the air leaving the compressor is 16.5 kJ/kg greater than that of the air entering. The cooling water in the compressor jackets absorbs heat from the air at the rate of 125 kJ/sec. Find : i) Power required to derive the compressor. ii) Ratio of inlet pipe diameter to outlet pipe diameter.	**8**
5.	a)	State Kelvin-Plank and clausius statements for second law of thermodynamics and prove their equivalence.	**5**
	b)	Show that the COP of heat pump is greater than the COP of refrigerator by unity.	**3**
	c)	An inventor claims to have developed a refrigerator system that removes heat from a cooled region at -5°C and transfer it to the surrounding air at 22°C, while maintaining its COP of 7.5. Is this claim reasonable? why ?	**5**

OR

6.	a)	Define heat engine, heat pump and refrigerator.	**3**
	b)	Explain Clausius Inequality & Entropy.	**4**
	c)	300 kW of heat is supplied at a constant temperature of 290°C to a heat engine. The engine rejects heat at 8.5°C. The following results were recorded : i) 215 kW is rejected ii) 150 kW is rejected iii) 75 kW is rejected Classify which of the results reports reversible, irreversible or impossible cycle.	**6**
7.	a)	Explain the following terms relating to steam formation : i) Laten heat of vaporisation ii) Dryness fraction iii) Degree of superheat iv) Wet steam v) Enthalpy of dry saturated steam vi) Triple point	**6**
	b)	One kg at steam of a pressure of 17.5 bar and dryness 0.95 is heated at a constant pressure, until it is completely dry. Determine : i) The increase in volume ii) The quantity of heat supplied and iii) The change in entropy	**7**

OR

8.	a)	Explain the method to determine dryness fraction of steam using combined separating and throttling calorimeter.	**6**

b) For determining the dryness fraction of sample of steam at 14 bar, it was passed through a throttling calorimeter attached to the steam main. The pressure and temperature after throttling process were recorded to be 1.2 bar and 120°C respectively. Calculate dryness fraction of steam before passing through the throttling unit. Take Cp = 2.1 kJ/kg k for superheated steam what is the minimum value of dryness fraction that can be determined by a such calorimeter if the pressure value are assume to be same ? **7**

9. a) Differentiate between vapour Carnot cycle and Rankine cycle. **4**

b) In a steam power plant using Rankine cycle, superheated steam is produced at 15 bar and 300°C and fed to the turbine where it is expanded to a condenser pressure of 0.8 bar. The saturated liquid coming out of condenser is pump back to the boiler by a feed pump. Assuming ideal processes. Determine : **9**

i) Condition of steam after isentropic expansion
ii) Rankine cycle efficiency
iii) Ideal steam consumption per kwatt-hr.

OR

10. a) Explain Reheat-Rankine cycle with neat diagram. Also write its advantages and disadvantages. **5**

b) A simple Rankine cycle works between pressure of 28 bar and 0.06 bar, the initial condition of steam being dry saturated at entry to turbine. Calculate the cycle efficiency, work ratio and specific steam consumption. **8**

11. a) Derive an expression for air standard efficiency of an Otto cycle in terms of compression ratio. Also draw P-V and T-S diagram for the same. **5**

b) In 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 constant pressure process is 1480°C **9**

Calculate :

i) The cut-off ratio   ii) Cycle efficiency
iii) Mean effective pressure.

OR

12. a) With the help of P-V and T-S diagram, compare the Otto, Diesel, and Dual cycle on the basis of - **6**

i) Same compression ratio and heat rejection
ii) Same maximum pressure and temperature

b) In an air standard Otto cycle that has heat addition of 2800 kJ/kg of air, a compression ratio of 8 and a pressure & temperature at the beginning of compression process of 1 bar & 300 k. Determine : **8**

i) Maximum pressure & temperature in cycle.
ii) The thermal efficiency
iii) Mean effective pressure

Take for air

$C_P = 1.005 \text{ kJ/kg k}$ $C_V = 0.718 \text{ kJ/kg k}$ $R = 0.287 \text{ kJ/kg k}$

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