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

Engineering Thermodynamics

P. Pages : 4

Time : Three Hours

TKN/KS/16/7372/7396

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 & Mollier chart is permitted.
12. The solutions must be supported with appropriate P-v, T-s, h-s diagrams.

1. a) Explain what you understand by thermodynamics equilibrium. **3**

b) A platinum wire is used as a resistance thermometer. The wire resistance was found to be 10 ohm and 16 ohm at ice point and steam point respectively, and 30 ohm at sulphur boiling point of 444.6°C. Find the resistance of the wire at 500°C, if the resistance varies with the temperature by the relation $R = R_0(1+\alpha t+\beta t^2)$. **6**

c) Show that work is a path functions, and not a properly. **4**

OR

2. a) Explain the terms : **6**
i) specific heat at constant volume and
ii) specific heat at constant pressure.
Also prove that $C_P - C_V = R$.

b) A gas in a piston-cylinder assembly undergoes an expansion process for which the relation between pressure and volume is given PV^n = constant. The initial pressure is 0.5 MPa, the initial volume is 0.15 m^3 and the final volume is 0.25 m^3. Determine the work transfer for the process in kJ if **7**
i) n = 0
ii) n = 1.0 and
iii) n = 1.5
Draw the process on P-V diagram.

3. a) What was the contribution of J. P. Joule in establishing the first law of thermodynamics ? What is a PMMI and why is it impossible. **4**

b) Write the first law of thermodynamics for open and closed system. Explain terms involved in it. **3**

c) A fluid system goes through a cycle comprising the following processes : 6
   i) process 1-2 isochoric heat addition of 235 kJ/kg
   ii) process 2-3 adiabatic expansion to its original pressure with loss of 70 kJ/kg in internal energy.
   iii) Process 3-1 isobaric compression to its original volume with heat rejection of 200 kJ/kg
   Prove that for cycle $\sum Q = \sum W$.

OR

4. a) State the general steady flow energy equation. Deduce the SFEE for - 6
   i) Nozzle ii) Gas turbine

   b) A stream of gases at 750 kN/m^2, 800°C and 150 m/s is passed through a turbine of a jet engine. The stream comes out of the turbine at 200 kN/m^2, 600°C and 300 m/s. The process may be assumed adiabatic. Determine the capacity of the turbine if the gas flow is 4 kg/s. The enthalpies of gas at the entry and exit of the turbine are 960 kJ/kg and 700 kJ/kg of gas respectively. 7

5. a) Explain the second law of thermodynamics. How can you modify the second law for practical applications. 4

   b) Show that the COP of a heat pump is greater than the COP of a refrigerator by unity. 3

   c) A household refrigerator is maintained at a temperature of 5°C. Every time the door is opened, warm material is placed inside, introducing an average of 420 kJ, but making only a small change in the temperature of the refrigerator. The door is opened 20 times a day, and the refrigerator operates at 15% of the ideal COP. The cost of work is Rs. 2.5 per kwh. What is the monthly bill for the refrigerator ? The atmospheric is at 30°C. 7

OR

6. a) What do you understand by the entropy principle ? What are the causes of entropy increase ? 4

   b) A heat engine receives reversibly 420 kJ/cycle of heat from a source at 327°C and reject heat reversibly to a sink at 27°C. There are no other heat transfer for each of the three hypothetical amounts of heat rejected. 6
   i) 210 kJ/cycle ii) 105 kJ/cycle iii) 315 kJ/cycle
   State the type of cycle i.e. reversible, irreversible and impossible.

   c) Establish the in equality of claussius. 4

7. a) Explain the following terms : 5
   i) Wet steam
   ii) Latent heat of vapourisation
   iii) Enthalpy of steam
   iv) Super heated steam
   v) Triple point

b) A rigid vessel contains 1 kg of a mixture of saturated water and saturated steam at a pressure of 0.15 MPa, when the mixture is heated, the state passes through the critical point. Determine : 8

i) the volume of the vessel
ii) the mass of liquid and of vapour in the vessel initially.
iii) the temperature of the mixture when the pressure has risen to 3 MPa, and
iv) the heat transfer required to produce the final state.

OR

8. a) Why cannot a throttling calorimeter measure the quality if the steam is very wet ? How is the quality measured then ? 6

b) Boiler steam at 8 bar, 250°C, reaches the engine control valve through a pipeline at 7 bar, 200°C. It is throttled to 5 bar before expanding in the engine to 0.1 bar, 0.9 dry. Determine per kg of steam - 7

i) the heat loss in the pipeline.
ii) the temperature drop in passing through the throttle valve,
iii) the work output of the engine
iv) the entropy change due to throttling and
v) the entropy change in passing through the engine.

9. a) What are the four basic components of a steam power plant ? Draw the vapour carnot cycle and Rankine cycle on T-S diagram. 5

b) A geothermal power plant utilizes steam produced by natural means under ground. Steam wells are drilled to tap this steam supply which is available at 4.5 bar and 175°C. The steam leaves the turbine at 100 mm of Hg absolute pressure. The turbine isentropic efficiency is 0.75. Calculate the efficiency of the plant. If the unit produces 12.5 MW, what is the steam flow rate ? 8

OR

10. a) What is the effect of reheating and regeneration on the following parameters 5

i) specific output
ii) mean temperature of heat addition
iii) cycle efficiency
iv) steam rate and
v) heat rate of a steam power plant.

b) A steam power plant uses the following cycle 8
Steam at boiler outlet = 120 bar, 400°C Reheat at 50 bar to 400°C Condenser at 0.1 bar
Determine :

i) Quality at turbine exhaust.
ii) Cycle efficiency &
iii) Steam rate.

11. a) Derive an expression for thermal efficiency of Diesel cycle. 6

b) An engine working on the otto cycle is supplied with air at 1 bar & 25°C. The compression ratio is 9:1 - Heat supplied is 2000 kJ/kg - Calculate **8**

i) Pressure and temperature at all salient points

ii) the cycle efficiency and iii) the mean effective pressure

(Take for air $C_P = 1.005\,kJ/kg$, $R = 0.287\ kJ/kgk$)

OR

12. a) Explain the effect of pressure ratio on the net output and efficiency of Brayton cycle. **4**

b) Explain the processes involved in dual cycle. **4**

c) For an air standard diesel cycle with a compression ratio of 15. Plot the efficiency as a functions of the cut-off ratio for cut-off ratios from 1 to 4. Comment on the result. **6**

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