SE. Sem IV / Prod / Thermal Engg. / Dec 09

159 : 2nd Exm.09-DD-(A)

Con. 5803-09. **(REVISED COURSE)** **SP-7775**

(3 Hours) **[Total Marks : 100**

N.B. (1) Question No.1 is **compulsory**.
(2) Attempt any **four** questions out of the remaining **six** questions.
(3) State assumptions **clearly**.
(4) Assume **suitable** data wherever **required**.

1. (a) Explain the following terms :— **4**
   (i) Thermal equilibrium
   (ii) Quasi-static process
   (iii) Homogeneous and heterogeneous systems
   (iv) Pure substance.

   (b) What do you mean by point function and path functions ? Prove that internal energy is a property of the system. **8**

   (c) A slow chemical reaction takes place in a fluid at the constant pressure of 0·1 MPa. The fluid is surrounded by a perfect heat insulator during the reaction which begins at state 1 and ends at state 2. The insulation is then removed and 105 kJ of heat flow to the surroundings as fluid goes to state 3. The following data are observed for the fluid at state 1, 2 and 3 :— **8**

State	V(m^3)	t(c)
1	0·003	20
2	0·3	370
3	0·06	20

   For the fluid system, calculate E_2 and E_3, if $E_1 = 0$.

2. (a) What do you mean by steady flow process ? Get the steady flow energy equation. **4**
   (b) Write the steady flow equation for :— **6**
   (i) Nozzle (ii) Compressor (iii) Heat exchanger.
   (c) Air flows steadily at the rate of 0·5 kg/s through an air compressor, entering at 7 m/s velocity, 100 KPa pressure and 0·95 m^3/kg volume and leaving at 5 m/s, 700 KPa and 0·19 m^3/kg. The internal energy of air leaving is 90 kJ/kg greater than that of air entering, cooling water in the compressor jackets absorbs heat from air at the rate of 58 kW — **10**
   (i) Compute the rate of work input to the air in kW
   (ii) Find the ratio of inlet pipe diameter to outlet pipe diameter.

3. (a) State and prove the equivalence of Kelvin-Planck and Clausius statements. **6**
   (b) State and prove Carnot's theorem. **6**
   (c) A reversible heat engine operates between two reservoirs at temperatures of 600°C and 40°C. The engine drives a reversible refrigerator which operates between reservoirs at temperatures of 40°C and –20°C. The heat transfer to heat engine is 2000 kj and net work output of combined engine refrigerator plant is 360 KJ. Evaluate the heat transfer to the refrigerant and net heat transfer to the reservoir at 40°C. **8**

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4. (a) Differentiate between Spark Ignition and Compression Ignition Engines. 4
   (b) Derive an expression for air standard efficiency of Otto cycle. 6
   (c) In an I. C. engine operating an dual cycle temperature of the working fluid (air) at the beginning of compression is 27°C. The ratio of maximum and minimum pressures of the cycle is 70 and compression ratio is 15. The amount of heat added at constant volume and at constant pressure are equal. Compute the air standard efficiency of the cycle. 10

5. (a) Derive an expression for optimum intercooler pressure in case of two stage compressor with perfect intercooling. 8
   (b) A single stage reciprocating compressor has 60 m^3/hr air entering at 1·013 bar, 15°C and air leaves at 7 bar. Compression follows polytropic process with index of 1·35. Considering negligible clearance determine mass of air delivered per minute, delivery temperature, indicated power and isothermal efficiency. 8
   (c) Explain in brief any one method of improving thermal efficiency of open cycle gas turbine power plant. 4

6. (a) State Fourier Law of Conduction. Explain each term along with units. 4
   (b) A cold storage room has wall made-up of 0·23 m of brick on the outside, 0·08 m of plastic foam and finally 1·5 cm of wood on the inside. The outside and inside air temperatures are 22°C and –2°C respectively. 10
   If the inside and outside heat transfer coefficients are 29 and 12 w/m^2k respectively and thermal conductivities of brick, foam and wood are 0·98, 0·02 and 0·17 w/mk respectively. Determine :—
      (i) Rate of heat removal by refrigeration if the total wall area is 90 m^2 and
      (ii) Temperature of the inside surface of brick.

7. (a) A vapor compression refrigerator works between the pressure limits of 60 bar and 25 bar. The working fluid is just dry at the end of compression and there is no undercooling of liquid before expansion. Determine :— 10
      (i) COP of the cycle
      (ii) Capacity of refrigerator if the fluid flow is at the rate of 5 kg/min.

   Use the data given below :—

Pressure (bar)	Saturation Temperature (k)	Enthalpy (kJ/kg)		Entropy (kJ/kg/c)	
		Liquid	Vapor	Liquid	Vapor
60	295	151·96	293·29	0·554	1·0332
25	261	56·32	322·58	0·226	1·2464.

   (b) Write short notes on any **two** of the following :— 10
      (i) Clausius Inequality
      (ii) Simple Carburettor
      (iii) Two Stroke Cycle SI Engine
      (iv) Window Air Conditioner.