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B037314(037)

B. Tech. (Third Semester) Examination, Nov.-Dec. 2021

(Mechanical Engg. Branch) AICTE

ENGINEERING THERMODYNAMICS

Time Allowed : Three hours

Maximum Marks : 100

Minimum Pass Marks : 35

***Note** : Attempt all questions. Each question carries equal makrs. Part (a) is compulsory and answer any **two** from (b), (c) and (d). Use standard notations. Steam table and Mollier chart is permitted.*

1. (a) Define an Adiabatic process. Write down the expression of work done for Adiabatic process. 4

   (b) A cylinder contains 1 kg of a certain fluid at an initial pressure of 20 bar. The fluid is allowed to expand

reversibly behind a piston according to a law $pV^2 =$ constant until the volume is doubled. The fluid is then cooled reversibly at constant pressure until the piston regains its original position; heat is then supplied reversibly with the piston firmly locked in position until the pressure rises to the original value of 20 bar. Calculate the net work done by the fluid, for an initial volume of 0·05 m^3. 8

(c) Show that the relation for a heat transfer during process 1-2 in polytrophic process is : 8

$$Q_{12} = \frac{\gamma - n}{\gamma - 1} \times \text{Polytropic work done}$$

(d) A nozzle is a device for increasing the velocity of a steadily flowing stream. At inlet to a certain nozzle, the fluid parameters are :

Enthalpy = 2850 kJ/kg; velocity = 50 m/s, area = 0·1 m^2 and specific volume = 0·18 m^3/kg. At the discharge end the enthalpy is 2650 kJ/kg and the specific volume is 0·49 m^3/kg.

Make calculations for the velocity of fluid at exit from the nozzle, mass flow rate of fluid, and the exit area of the nozzle.

The nozzle is horizontal and there is negligible heat loss from it. 8

2. (a) What do you mean by Perpetual Motion Machine of second kind (PMM-II)? Why is it considered as a hypothetical machine? 4

(b) Two reversible heat engine A and B are arranged in series. A rejecting heat directly to B. A receives 200 kilo Joule at a temperature of 421°C from a hot source while engine B is in communication with the cold sink at a temperature of 4·4°C. If the work output of A is twice that of B.

Calculate :

(i) Intermediate temperature between A and B

(ii) Efficiency of each engine and

(iii) Heat rejected to cold sink 8

(c) State the Kelvin-Planck and Clausius statements of the second law of thermodynamics and establish the equivalence between them. 8

(d) Three identical finite body of constant heat capacity are at temperature 300 K, 300 K and 100 K. If no work or heat is supplied from outside. What will be

the highest temperature to which any one of the body can be raised by the operation of heat engine and refrigerator? 8

3. (a) What do you mean by Dead state and Availability. 4

(b) Write short notes on : (any **two**) 8

(i) Helmholtz and Gibb's function

(ii) Gouy's Stodola theorem

(iii) Second law efficiency

(c) A system at 450 K receives 225 kJ/s of heat energy from a source at 1500 K, and the temperature of both the system and source remain constant during the heat transfer process.

Determine :

(i) Net change in entropy

(ii) Available energy of heat source and system

(iii) Decrease in available energy 8

(d) One kg of air is contained in a piston cylinder assembly at 10 bar pressure and 500 K temperature. The piston moves outwards and the air expands to 2 bar pressure and 350 K temperature. Make calculations for : 8

(i) The availability in the initial and final states

(ii) The maximum useful work

Assume that the system is insulated and the environmental conditions are 1 bar and 290 K further for air : $R = 0{\cdot}287$ kJ/kg K, $C_v = 0{\cdot}718$ kJ/kg K, $C_p = 1{\cdot}005$ kJ/kg K.

4. (a) What do you mean by "Law of corresponding states"? 4

(b) A spherical vessel of 1·5 m diameter containing air at 315 K is evacuated until the vacuum inside the vessel is 730 mm of mercury; the evacuation process is carried out at constant temperature. Determine the mass of air pumped out. Proceed to calculate the pressure in the tank if subsequently the air is cooled to 275 K. For air $R = 287$ J/kg K and take atmospheric pressure equal to 760 mm of mercury. 8

(c) At critical point for all gases obeying Vander Waal's equation of state, show that :

$$\frac{P_c V_c}{RT_c} = 0{\cdot}375$$

Where P_c = Critical pressure, T_c = Critical temperature and V_c = Critical volume. 8

(d) A vessel contains 10 kg of oxygen, 8 kg of nitrogen and 25 kg of carbondioxide at 375 K temperature and 250 kPa pressure, make calculations for the capacity of the vessel, the partial pressure of each gas present in the vessel, and the total pressure in the vessel when the temperature is raised to 450 K. 8

5. (a) Explain dryness fraction and wetness fraction. When dryness fraction is expressed in terms of percentage, what do you call it? 4

(b) A sample of steam at 5 bar is stated to have an enthalpy of 2350 kJ/kg. Make calculations for the specific volume, internal energy and entropy of this sample of steam. 8

(c) 2 kg of steam occupying 0·3 m^3 at 15 bar is expanded according to the law $pv^{1.3} = C$, to a pressure of 1·5 bar. 8

Calculate :

(i) Work done

(ii) Condition of steam at the end of expansion

(d) Steam initially at 1·5 MPa, 300°C expands reversibly and adiabatically in a steam turbine to 40°C. Determine ideal work output of the turbine per kg of steam. 8