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Code : 021307

B.Tech 3rd Semester Exam., 2017

THERMODYNAMICS

Time : 3 hours *Full Marks* : 70

Instructions :

(i) The marks are indicated in the right-hand margin.

(ii) There are ***NINE*** *questions in this paper.*

(iii) Attempt ***FIVE*** *questions in all.*

(iv) Question No. ***1*** *is compulsory.*

1. Choose the correct option (any *seven*) : 2×7=14

(a) In a free expansion process involving ideal gas

(i) p = constant

(ii) v = constant

(iii) u = constant

(iv) w = constant

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(b) The efficiency of a Carnot engine is given as 0·75. If the cycle direction is reversed, what will be the value of COP of the Carnot refrigerator?

(i) 0·271

(ii) 0·33

(iii) 1·27

(iv) 2·3

(c) The first law of thermodynamics gives $dU = \delta Q - \delta W$ and second law tells that $dS > \frac{\delta Q}{T}$. In which of the way these two laws can be combined and written?

(i) $dU \geq TdS - pdV$

(ii) $dU \leq dS - pdV$

(iii) $dU \leq TdS + pdV$

(iv) $dU = TdS - pdV$

(d) With increase in pressure, the latent heat of steam

(i) decreases

(ii) increases

(iii) remains the same

(iv) behaves unpredictably

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(e) During dryness fraction measurement of steam using throttling calorimeter, the wet state of steam is throttled so as to lie in

(i) wet state

(ii) dry and saturated state

(iii) superheated state

(iv) supersaturated state

(f) Air standard efficiency of Diesel cycle is a function of

(i) compression ratio and cut-off ratio

(ii) compression ratio and ratio of maximum to minimum temperature

(iii) compression ratio and ratio of maximum to minimum pressure

(iv) compression ratio and ratio of exhaust temperature to inlet temperature

(g) The thermal efficiency of power plant lies in the range of

(i) 20% to 30%

(ii) 30% to 40%

(iii) 40% to 50%

(iv) 50% to 60%

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(h) Select the correct order for flue gas flow in a steam power plant layout.

(i) Economiser, superheater and air-preheater

(ii) Air-preheater, economiser and superheater

(iii) Economiser, air-preheater and superheater

(iv) Superheater, economiser and air-preheater

(i) Humidity ratio can be expressed in terms of partial pressure of dry air (p_a) and water vapour (p_v) as

(i) $0 \cdot 622\left(\frac{p_a}{p_v}\right)$

(ii) $0 \cdot 622\left(\frac{p_v}{p_a}\right)$

(iii) $0 \cdot 622\left(\frac{p_v}{p_v - p_a}\right)$

(iv) $0 \cdot 622\left(\frac{p_v - p_a}{p_v}\right)$

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2. *(a)* Derive the work done in process pv^{γ} = constant. 5

(b) A mass of 8 kg gas expands within a flexible container so that the p-v relationship is of the form pv^{γ} = constant. The initial pressure is 1000 kPa and the initial volume is 1 m^3. The final pressure is 5 kPa. If specific internal energy of the gas decreases by 40 kJ/kg, then find the heat transfer in magnitude and direction. 9

3. *(a)* Describe indicator thermal efficiency and brake thermal efficiency. 5

(b) A closed cylinder of 0·25 m diameter is fitted with a light frictionless piston. The piston is retained in position by a catch in the cylinder wall and volume on one side of the piston contains air at a pressure of 750 kN/m^2. The volume on the other side of the piston is evacuated. A helical spring is mounted coaxially with the cylinder in this evacuated space to give a force of 120 N on the piston in this position. The catch is released and the piston travels along the cylinder until it comes to rest after a stroke of 1·2 m. The piston is then held in its position of maximum travel

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by a ratchet mechanism. The spring force increases linearly with the piston displacement to a final value of 5 kN. Calculate the work done by the compressed air on the piston. 9

4. *(a)* Describe a dual cycle. 5

(b) 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 the constant pressure process is 1480 °C. Calculate *(i)* the cut-off ratio, *(ii)* the heat supplied per kg of air, *(iii)* the cycle efficiency and *(iv)* the mean effective pressure. 9

5. *(a)* Compare the Otto, Diesel and Dual cycle for same compression ratio. 5

(b) In a steam power plant, the condition of steam at inlet to steam generator is 20 bar and 300 °C and the condenser pressure is 0·1 bar. Two feed water heaters operate at optimum temperatures. Determine the *(i)* quality of steam at turbine exhaust, *(ii)* net work per kg, *(iii)* cycle efficiency and *(iv)* steam rate. Neglect pump work. 9

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6. (a) Show that the decrease in available energy when heat is transferred through a finite temperature difference. 5

(b) Define heat pump and refrigeration plant, and discuss their working principles with coefficient of performances. 9

7. (a) Define irreversibility and describe various causes of irreversibility. 7

(b) A certain water heater operates under steady flow conditions receiving 4·2 kg/s of water at 75 °C temperature, enthalpy 313·93 kJ/kg. The water is heated by mixing with the steam which is supplied to the heater at temperature 100·2 °C and enthalpy 2676 kJ/kg. The mixture leaves the heater as liquid water at temperature 100 °C and enthalpy 419 kJ/kg. How much steam must be supplied to the heater per hour? 7

8. (a) Describe different modes of energy storage in a thermodynamic system. 5

(b) Describe the terms 'specific heat at constant volume', 'enthalpy' and 'specific heat at constant pressure'. 3×3=9

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9. (a) A vessel of volume 0·04 m^3 contains a mixture of saturated water and saturated steam at a temperature of 250 °C. The mass of the liquid present is 9 kg. Find the pressure, the mass, the specific volume, the enthalpy, the entropy and the internal energy. Use the steam table. 10

(b) Write four Maxwell's equations. 4

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