B 2326

B.E./B.Tech. DEGREE EXAMINATION, MAY/JUNE 2007.

Second Semester

Mechanical Engineering

ME 132 — THERMODYNAMICS

Time : Three hours   Maximum : 100 marks

Answer ALL questions.

Approved Thermodynamic charts and tables permitted for use.

PART A — (10 × 2 = 20 marks)

1.   Briefly explain "the concept of continuum".

2.   What are point functions and path functions? Explain giving examples for each.

3.   Mention any four factors which render processes irreversible

4.   1 kg water boils melts at constant atmospheric pressure and at 100°C to form liquid water. If the latent heat of vaporisation of water is 2258 kJ/kg calculate the entropy change during this process.

5.   Define the term quality and give expressions to determine the entropy of wet steam of given quality x, in terms of entropy of saturated liquid and dry saturated vapour.

6.   Deduce the expression for the molecular weight of the mixture of two non reacting ideal gases A and B.

7.   Sketch a skeleton compressibility chart and show the constant reduced temperature characteristics on it.

8.   What are reduced properties? Give their significance?

9.   Define : (a) sensible enthalpy and (b) enthalpy of formation.

10.   Calculate the Air-Fuel ratio required for complete combustion of ethane (C_2H_6) on mass basis.

11. (a) (i) Prove the Carnot theorem that "all reversible engines operating between given source and sink have the same thermal efficiency."

(6)

(ii) Air of mass 0.5 kg is compressed reversible and adiabatically from 80 kPa, 60°C, to 0.4 MPa, and is then expanded at constant pressure to the original volume. Sketch the process on p-v plane and determine the heat transfer and work transfer. For air assume $R = 0.287$ kJ/kgK and $C_v = 0.713$ kJ/kgK (10)

Or

(b) Air at 101.325 kPa, 20°C is taken into a gas turbine power plant at a velocity of 140 m/s through an opening of 0.15 m² cross-sectional area. The air is compressed, heated, expanded through a turbine, and exhausted at 0.18 Mpa, 150°C through an opening of 0.10 m² cross-sectional area. The power output is 375 kW. Calculate the net amount of heat added to the air in kJ/kg. Assume the air obeys the law $pv = 0.287$ (t + 273), where p is the pressure in kPa, v is the specific volume in m³/kg, and t is in temperature in °C. Take $C_p = 1.005$ kJ/kg.K (16)

12. (a) (i) Prove that for an ideal gas $C_p - C_v = R$. (6)

(ii) A closed system consists of 1 kg of air which is initially at 1.5 bar and 67°C. The volume doubles as the system undergoes a process according to the law $PV^{1.2} = C$. Find the work done, heat transfer and the change in entropy during this process. For air $R = 0.287$ kJ/kgK and $\gamma = 1.4$. (10)

Or

(b) (i) Apply the steady flow energy equation to a Turbine and deduce an expression for work. (6)

(ii) An air compressor takes in air at 100 kPa,17°C and delivers it at 1 MPa, 600 K to a constant-pressure cooler, which it exits at 300 K. Making suitable assumptions find the specific compressor work and the specific heat transfer. For air R = 0.287 kJ/kgK and $\gamma = 1.4$ (10)

13. (a) (i) A volumetric analysis of a gaseous mixture yields the following results :

CO_2 = 12.0%, O_2 = 4.0%, N_2 = 82.0%, CO = 2.0%

Determine the analysis on mass basis and determine the molecular weight and the gas constant on mass basis for the mixture. Assume ideal gas behaviour. (10)

(ii) State any one equations of state for real gas and show how the deviation from ideal gas behaviour is accounted for. (6)

Or

(b) (i) Deduce the Maxwell relations from thermodynamic property relations (8)

(ii) Using Maxwell relations deduce the Clausius -Clapeyron equation. (8).

14. (a) (i) A vessel having a volume of 5 m^3 contains 0.05 m^3 of saturated liquid water and 4.95 m^3 of saturated water vapour at 0.1 MPa. Heat is transferred until the vessel is filled with saturated vapour. Determine the heat transfer, work done and change in entropy for the process. (12)

(ii) Explain with a neat sketch the construction of the Mollier diagram and give its use in thermodynamic process representation (4)

Or

(b) (i) A compressor is used to bring saturated water vapour at 1 MPa up to 17.5 MPa, where the actual exit temperature is 650°C. Find the isentropic compressor efficiency and entropy generation (10)

(ii) Define : Specific humidity, relative humidity and dew point. (6)

15. (a) (i) Explain how the constant volume heating value of a fuel can be computed using first law applied to combustion systems. (8)

(ii) Briefly explain how the adiabatic flame temperature for a given fuel-air mixture gets affected with equivalence ratio. (8)

Or

3 B 2326

(b) (i) Explain how the Orsat apparatus could be used to obtain the mole fractions of the flue gas constituents. (8)

   (ii) Octane (C_8H_{18}) is burnt with 90% theoretical air. The incomplete combustion produces CO_2, CO, H_2O and N_2 in the products. Calculate the air-fuel ratio by mass and also the mass fraction of the constituents of the dry combustion products. (8)

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