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B.E./B.Tech. DEGREE EXAMINATION, APRIL/MAY 2017.

Third Semester

Mechanical Engineering

ME 6301 — ENGINEERING THERMODYNAMICS

(Common to Automobile Engineering, Mechanical and Automation Engineering)

(Regulations 2013)

Time : Three hours Maximum : 100 marks

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. State and explain the Zeroth law and its application.

2. Apply steady flow energy equation for a nozzle and state the assumptions made.

3. What is PMM2 and why is it impossible?

4. What do you understand by high grade energy and low grade energy?

5. What are compressed solid and compressed liquid?

6. What are the methods for improving the performance of the Rankine cycle?

7. What is meant by generalized compressibility chart? and what are its features?

8. What is the value of Joule — Thomson coefficient for an ideal gas? Why?

9. State and prove the Amagat's law of partial volume.

10. What is sensible cooling?

PART B — (5 × 13 = 65 marks)

11. (a) A gas occupies 0.3 m^3 at 2 bar. It executes a cycle consisting of processes :

(i) 1 - 2, constant pressure with work interaction of 15 kJ

(ii) 2 - 3, compression process which follows the law pV = C and $U_3 = U_2$ and

(iii) 3 - 1, constant volume process, and reduction in internal energy is 40 kJ

Neglecting the changes in Kinetic energy and Potential energy. Draw pV diagram for the process and determine net work transfer for the cycle. Also show that first law is obeyed by the cycle.

Or

(b) In a gas turbine, the gases enter the turbine at the rate of 5 kg/s with a velocity of 50 m/s and the enthalpy of 900 kJ/kg and leaves the turbine with 150 m/s and the enthalpy of 400 kJ/kg. The loss of heat from the gas to the surroundings is 25 kJ/kg. Assume R = 0.285 kJ/kg K, Cp = 1.004 kJ/kg K and the inlet conditions to be at 100 kPa and 27°C. Determine the work done and diameter of the inlet pipe.

12. (a) A heat pump working on the Carnot cycle takes in heat from a reservoir at 5°C and delivers heat to a reservoir at 60°C. The heat pump is driven by a reversible heat engine which takes in heat from reservoir at 840°C and rejects heat to a reservoir at 60°C. The reversible heat engine also drives a machine that absorbs 30 kW. If the heat pump extracts 17 kJ/s from 5°C reservoir, determine

(i) the rate of heat supply from the 840°C source, and

(ii) the rate of heat rejection to the 60°C sink

Or

(b) Air flows through an adiabatic compressor at 2 kg/s. The inlet conditions are 1 bar and 310 K and the exit conditions are 7 bar and 560 K. Compute the net rate of energy transfer and the irreversibility. Take $T_0 = 298$ K

13. (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.

Or

(b) A reheat Rankine cycle receives steam at 35 bar and 0.1 bar. Steam enters the first stage steam turbine 350°C. If reheating is done at 8 bar to 350°C, calculate the specific steam consumption and reheat Rankine cycle efficiency.

14. (a) 10 kmol of methane gas is stored in 5 m+ container at 300 K. Calculate the pressure by

(i) ideal gas equation and

(ii) van der Waals equation.

Use the following constants $a = 228.296$ kPa.m^6/kmol^2 and $b = 0.043$ m^3/kmol for the Vander Waals equation.

Or

(b) The latent heat of vaporization at 1 bar pressure is 2258 kJ/kg and the saturation temperature is 99.4°C. Calculate the saturation temperature at 2 bar pressure using Clausius — Clapeyron equation. Verify the same from the steam table data.

15. (a) Atmospheric air at 101.325 kPa and 288.15 K contains 21% oxygen and 79% nitrogen, by volume. Calculate the

(i) mole fractions, mass fractions and partial pressures of oxygen and nitrogen and

(ii) molar mass, gas constant and density of the air.

Take Molar mass of oxygen and nitrogen as 32 and 28 kg/kmol.

Or

(b) Air at 20°C, 40% RH is mixed adiabatically with air at 40°C, 40% RH in the ratio of 1 kg of the former with 2 kg of the latter (on dry basis). Determine the specific humidity and the enthalpy of the mixed stream.

PART C — (1 × 15 = 15 marks)

16. (a) A quantity of air undergoes a thermodynamic cycle consisting of three processes. Process 1 – 2 : Constant volume heating from $P_1 = 0.1$ MPa, $T_1 = 15$°C, $V_1 = 0.02$ m^3 to $P_2 = 0.42$ MPa. Process 2-3 : Constant pressure cooling. Process 3-1 : Isothermal heating to the initial state. Employing the ideal gas model with $C_p = 1$ kJ/kgK, evaluate the change of entropy for each process. Sketch the cycle on p-v and T-s coordinates.

Or

(b) Air at 80 kpa, 27°C and 220 m/s enters a diffuser at a rate of 2.5 kg/s and leaves at 42°C. The exit area of the diffuser is 400 cm^2. The air is estimated to lose heat at a rate of 18 kJ/s during this process. Determine :

(i) the exit velocity and

(ii) the exit pressure of the air.

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