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B.E./B.Tech. DEGREE EXAMINATION, NOVEMBER/DECEMBER 2013.

Third Semester

Mechanical Engineering

ME 1201/ME 1202/070120006 — ENGINEERING THERMODYNAMICS

(Common to Production Engineering)

(Regulation 2004/2007)

(Common to B.E. (Part-Time) Second Semester – Mechanical Engineering – Regulation 2005)

Time : Three hours Maximum : 100 marks

(Use of standard steam table, Mollier diagram and psychometric chart permitted)

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. What is meant by thermodynamics system? How do you classify it?
2. Define : Internal energy.
3. Why is the second law, called a directional law of nature?
4. Define : Availability.
5. Draw a P-T (Pressure - Temperature) diagram for a pure substance.
6. Compare Rankine cycle and Carnot cycle.
7. How does the Vanderwaal's equation differ from the ideal gas equation of state?
8. What is Joule - Thomson co-efficient?
9. Define : Sensible heat and latent heat.
10. Define the approach and range of a cooling tower.

PART B — (5 × 16 = 80 marks)

11. (a) (i) Define : Open, closed and isolated system. (6)

(ii) Two mercury in glass theermometers are made of identical materials and are accurately calibrated at 0°C and 100°C. One has a tube of constant diameter, while the other has a tube of conical bore, ten percent greater in diameter at 100°C than at 0°C. Both thermometers have the length between 0 and 100 subdivided uniformly. What will be the straight bore thermometer read in a place where the conical bore thermometer reads 50°C? (10)

Or

(b) An insulated rigid tank initially contains 0.7 kg of helium at 27°C and 350 kPa. A paddle wheel with a power rating of 0.015 KW is operated within the tank for 30 min. Determine

(i) The final temperature and (8)

(ii) The final pressure of the helium gas. (8)

12. (a) 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 the heat engine is 2000 kJ and the network output of the combined engine refrigerator plant is 360 kJ.

(i) Evaluate the heat transfer to the refrigerant and the net heat transfer to the reservoir at 40°C. (8)

(ii) Reconsider (i) given that the efficiency of the heat engine and the COP of the refrigerator are each 40% of their maximum possible values. (8)

Or

(b) Water at 200 kPa and 10°C enters a mixing chamber at a rate of 150 kg/min where it is mixed steadily with steam entering at 200 kPa and 150°C. The mixture leaves the chamber at 200 kPa and 70°C and heat is lost to the surrounding air at 20°C at a rate of 190 kJ/min neglecting the changes in kinetic and potential energies, determine the rate of entropy generation during this process? (16)

13. (a) A 28 mm diameter cylinder fitted with a frictionless leak proof piston contains 0.02 Kg of steam at a pressure of 0.6 MPa and a temperature of 200°C. As the piston moves slowly outwards through a distance of 305 mm. The steam undergoes fully resisted expansion during which the steam pressure P and the steam volume V are relates by PV^n = constant, where n is a constant. The final pressure of the steam is 0.12 MPa. Determine :

(i) The value of n (6)

(ii) The work done by the steam (5)

(iii) The magnitude and sign of heat transfer. (5)

Or

(b) In a steam power plant, the condition of steam turbine inlet is 80 bar, 500°C and the condenser pressure is 0.1 bar. The heat source comprises a steam of exhaust gases from a gas turbine discharging at 560°C and 1 atm pressure. The minimum temperature allowed for the exhaust gas steam is 450K. The mass flow rate of the hot gases is such that the heat input rate to the steam cycle is 100MW. The ambient condition is given by 300K and 1 atm, Determine η_1 work ratio and η_2 of the following cycles.

(i) Basic Rankine cycle, without superheat (4)

(ii) Rankine cycle with superheat (4)

(iii) Rankine cycle with reheat such that steam expands in the HP turbine until it exits as dry saturated vapour. (4)

(iv) ideal regenerative cycle, with the exit temperature of the exhaust gas steam taken as 320°C, because the saturation temperature of steam at 80 bar is close to 300°C. (4)

14. (a) (i) Show that for an ideal gas, $C_p - C_v = R$ (4)

(ii) A mass of air is initially at 260°C and 700kPa and occupies 0.028 m^3. The air 5 expanded at constant pressure to 0.084 m^3. A plolytropic process with n = 1.50 is then carried out followed by a constant temperature process which completes a cycle. All the processes are reversible.

(1) Sketch the cycle in the P-V and T-S planes. (4)

(2) Find the heat received and heat rejected in the cycle. (4)

(3) Find the efficiency of the cycle. (4)

Or

(b) (i) Define : Maxwell relations. (8)

(ii) Determine the enthalpy change and the entropy change of oxygen per unit mole as it undergoes a charge of state from 220 K and 5 MPa to 300K and 10 MPa.

(1) by assuming ideal-gas behaviour (4)

(2) by accounting for the deviation from ideal-gas behaviour. (4)

15. (a) A room contains air at 1 atm, 26°C and 70% relative humidity using the psychrometric chart, determine

(i) The specific humidity (4)

(ii) The enthalpy in KJ/Kg dry air (3)

(iii) The wet-bulb temperature (3)

(iv) The dew-point temperature (3)

(v) The specific volume of the air, in m^3/Kg dry air. (3)

Or

(b) Saturated air leaving the cooling section of an air-conditioning system at 14°C at a rate of 50 m^3/min is mixed adiabatically with the outside air at 32°C and 60% relative humidity at a rate of 20 m^3/min. Assuming that the mixing process occurs at a pressure of 1 atm, determine the specific humidity, the relative humidity, the dry-bulb temperature, and the volume flow rate of the mixture. (16)
