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Question Paper Code : 51620

B.E./B.Tech. DEGREE EXAMINATION, MAY/JUNE 2014.

Third Semester

Mechanical Engineering

ME 2202/ME 33/ME 1201/080190005/10122 ME 303/AT 2203/AT 36/ 10122 AU 302 — ENGINEERING THERMODYNAMICS

(Common to Automobile Engineering)

(Regulations 2008/2010)

(Common to PTME 2202 Engineering Thermodynamics for B.E. (Part-Time) Third Semester Mechanical Engineering – Regulation 2009)

Time : Three hours Maximum : 100 marks

(Use of approved thermodynamics tables, Mollier diagram, Psychometric chart and Refrigerant property tables permitted in the Examination)

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. Define: Thermodynamic Equilibrium.

2. Differentiate between Point function and Path function.

3. State: Kelvin-Planck statement.

4. Write Carnot theorem and its corollaries.

5. Draw a p-T (pressure-temperature) diagram for a pure substance.

6. Mention the possible ways to increase thermal efficiency of Rankine cycle.

7. What are the assumptions made to derive ideal gas equation analytically using the kinetic theory of gases?

8. Using Clausius-Claperyon's equation, estimate the enthalpy of vaporization at 200°C : $v_g = 0.1274$ m^3/kg; $v_f = 0.001157$ m^3/kg; dp/dT = 32 kPa/K.

9. Define: Adiabatic saturation temperature.

10. What is by-pass factor?

PART B — (5 × 16 = 80 marks)

11. (a) Determine the heat transfer and its direction for a system in which a perfect gas having molecular weight of 6 is compressed from 101.3 kPa, 20°C to a pressure of 600 kPa following the law $pV^{1.3}$ = constant. Take specific heat at constant pressure of gas as 1.7 kJ/kg.K.

Or

(b) In a gas turbine installation air is heated inside heat exchanger up to 750°C from ambient temperature of 27°C. Hot air then enters into gas turbine with the velocity of 50 m/s and leaves at 600°C. Air leaving turbine enters a nozzle at 60 m/s velocity and leaves nozzle at temperature of 500°C. For unit mass flow rate of air, determine the following assuming adiabatic expansion in turbine and nozzle,

(i) Heat transfer to air in heat exchanger

(ii) Power output from turbine

(iii) Velocity at exit of nozzle. Take cp for air as 1.005 kJ/kg°K.

12. (a) (i) A reversible heat pump is used to maintain a temperature of 0°C in a refrigerator when it rejects the heat to the surroundings at 25°C. If the heat removal rate from the refrigerator is 1440 kJ/min, determine the C.O.P. of the machine and work input required.

(ii) If the required input to run the pump is developed by a reversible engine which receives heat at 380°C and rejects heat to atmosphere, then determine the overall C.O.P. of the system.

Or

(b) 5 m^3 of air at 2 bar, 27°C is compressed up to 6 bar pressure following $pv^{1.3}$ = constant. It is subsequently expanded adiabatically to 2 bar. Considering the two processes to be reversible, determine the network, net heat transfer, change in entropy. Also plot the processes on T-S and P-V diagrams.

13. (a) A vessel having a capacity of 0.05 m^3 contains a mixture of saturated water and saturated steam at a temperature of 245°C. The mass of the liquid present is 10 kg. Find the following

(i) The pressure,

(ii) The mass,

(iii) The specific volume,

(iv) The specific enthalpy,

(v) The specific entropy, and

(vi) The specific internal energy.

Or

(b) A steam power plant operates on a theoretical reheat cycle. Steam at boiler at 150 bar, 550°C expands through the high pressure turbine. It is reheated at a constant pressure of 40 bar to 550°C and expands through the low pressure turbine to a condenser at 0.1 bar. Draw T-s and h-s diagrams. Find:

(i) Quality of steam at turbine exhaust

(ii) Cycle efficiency

(iii) Steam rate in kg/kWh.

14. (a) Derive the Maxwell relations and explain their importance in thermodynamics.

Or

(b) The pressure and temperature of mixture of 4 kg of O_2 and 6 kg of N_2 are 4 bar and 27°C respectively. For the mixture determine the following:

(i) The mole fraction of each component ;

(ii) The average molecular weight;

(iii) The specific gas constant;

(iv) The volume and density:

(v) The partial pressures and partial volumes.

15. (a) An air-water vapour mixture enters an air-conditioning unit at a pressure of 1.0 bar, 38°C DBT, and a relative humidity of 75%. The mass of dry air entering is 1 kg/s. The air-vapour mixture leaves the air-conditioning unit at 1.0 bar, 18°C, 85% relative humidity. The moisture condensed leaves at 18°C.

Determine the heat transfer rate for the process.

Or

(b) It is required to design an air-conditioning system for an industrial process for the following hot and wet summer conditions

Outdoor conditions	32°C DBT and 65% RH.
Required air inlet conditions	25°C DBT and 60% RH.
Amount of free air circulated	250 m^3/min
Coil dew temperature	13°C.

The required condition is achieved by first cooling and dehumidifying and then by heating. Calculate the following (Solve this problem with the use of psychrometric chart):

(i) The cooling capacity of the cooling coil and its by-pass factor.

(ii) Heating capacity of the heating coil in kW and surface temperature of the heating coil if the by-pass factor is 0.3.

(iii) The mass of water vapour removed per hour.