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B.E./B.Tech. DEGREE EXAMINATION, MAY/JUNE 2013.

Third Semester

Mechanical Engineering

ME 2202/ME 33/10122 ME 303/ME 1201/080190005 — ENGINEERING THERMODYNAMICS

(Regulation 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 thermodynamic tables, Mollier diagram, Psychometric chart and Refrigerant property tables permitted in the examination)

Answer ALL questions.

PART A — ($10 \times 2 = 20$ marks)

1. Define flow energy.

2. What are the conditions for steady flow process?

3. State Kelvin Planck's second law statement.

4. What is the difference between adiabatic and isentropic processes?

5. Define Exergy.

6. What is meant by dead state?

7. Define Joule–Thompson Coefficient.

8. Find the mass of 0.7 m^3 of wet steam at 150°C and 90% dry.

9. When is humidification of air necessary?

10. How does the wet bulb temperature differ from the dry bulb temperature?

PART B — (5 × 16 = 80 marks)

11. (a) A three process cycle operating with nitrogen as the working substance has constant temperature compression at 34°C with initial pressure 100 kPa. Then the gas undergoes a constant volume heating and then polytropic expansion with 1.35 as index of compression. The isothermal compression requires −67kJ/kg of work. Determine

(i) P, v and T around the cycle

(ii) Heat in and out

(iii) Net work.

For nitrogen gas, C_v = 0.7431kJ/kg-K. (16)

Or

(b) (i) Derive the steady flow energy equation, stating the assumptions made. (6)

(ii) Prove that energy is a property of a system. (5)

(iii) Enumerate and explain the limitations of first law of thermodynamics. (5)

12. (a) (i) Prove that increase in entropy in a polytropic process is $\Delta s = mc_v \frac{\gamma - n}{n} \ln\left(\frac{p_1}{p_2}\right)$. (6)

(ii) An irreversible heat engine with 66% efficiency of the maximum possible, is operating between 1000 K and 300 K. If it delivers 3 kW of work, determine the heat extracted from the high temperature reservoir and heat rejected to low temperature reservoir. (10)

Or

(b) (i) Helium enters an actual turbine at 300 kPa, 300°C and expands to 100 kPa, 150°C. Heat transfer to atmosphere at 101.325 kPa, 25°C amounts to 7 kJ/kg. Calculate the entering stream availability, leaving stream availability and the maximum work. For helium, C_p = 5.2kJ/kg and molecular weight = 4.003kg/kg-mol. (10)

(ii) List out and explain various causes of irreversibility. (6)

13. (a) (i) Steam at 30 bar and 350°C is expanded in a non flow isothermal process to a pressure of 1 bar. The temperature and pressure of the surroundings are 25°C and 100 kPa respectively. Determine the maximum work that can be obtained from this process per kg of steam. Also find the maximum useful work. (10)

(ii) With the aid of T-v diagram explain various phases of conversion of ice at −20°C to steam at 125°C. (6)

Or

(b) (i) With the help of a schematic diagram, explain the regenerative Rankine cycle and derive the expression for its efficiency. Also represent the process in p-v and T-s diagram. (8)

(ii) Steam at 50 bar, 400°C expands in a Rankine cycle to 0.34 bar. For a mass flow rate of 150 kg/sec of steam, determine

(1) Power developed

(2) Thermal efficiency

(3) Specific steam consumption. (8)

14. (a) (i) Derive Clausius–Clapeyrons equation. What assumptions are made in this equation? (10)

(ii) Consider an ideal gas at 303 K and 0.86 m³/kg. As a result of some disturbance the state of the gas changes to 304 K and 0.87 m³/kg. Estimate the change in pressure of the gas as the result of this disturbance. (6)

Or

(b) (i) From the basic principles, prove the following $c_p - c_v = -T\left(\frac{\partial v}{\partial T}\right)_p^2 \left(\frac{\partial p}{\partial v}\right)_T$. (8)

(ii) Verify the validity of Maxwell's relation, $\left(\frac{\partial s}{\partial p}\right)_T = -\left(\frac{\partial v}{\partial T}\right)_p$ for steam at 300°C and 500 kPa. (8)

15. (a) (i) Derive the sensible heat factor for cooling and dehumidification process. Also explain the process. (6)

(ii) One kg of air at 40°C dry bulb temperature and 50% relative humidity is mixed with 2kg of air at 20°C dry bulb temperature and 20°C dew point temperature. Calculate the temperature and specific humidity of the mixture. (10)

Or

(b) (i) Prove that specific humidity of air is $\omega = 0.622 \frac{p_v}{p_b - p_v}$. (6)

(ii) With the aid of model psychometric chart explain the following processes.

(1) Adiabatic mixing

(2) Evaporative cooling. (10)

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