Reg. No. : | | | | | | | | | | | |

Question Paper Code : 41374

B.E./B.Tech. DEGREE EXAMINATIONS, NOVEMBER/DECEMBER 2024.

Third/Fourth Semester

Mechanical Engineering

ME 3391 – ENGINEERING THERMODYNAMICS

(Common to : Manufacturing Engineering/Mechanical Engineering (Sandwich)/ Agricultural Engineering)

(Regulations 2021)

Time : Three hours Maximum : 100 marks

Use of Approved Steam Tables and Mollier Chart is permitted.

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. Differentiate between path and process function.

2. State zeroth law of thermodynamics.

3. Draw the simple layout of Heat Pump and write its COP equation.

4. Determine the specific enthalpy and specific entropy of a steam at 130 °C when the steam is 75% dry.

5. How reheat cycle is improved from ideal Rankine cycle?

6. Write one example for an open system and a closed system.

7. What are pure substances?

8. Define dryness fraction.

9. Differentiate ideal and real gases.

10. Write the Van der Waal's relation.

PART B — (5 × 13 = 65 marks)

11. (a) (i) With neat sketches explain the different types of thermodynamics system. (7)

(ii) Derive the expression for the displacement work. (6)

Or

(b) In a steady flow process, a substance flows at the rate of 300 kg/min. It enters at a pressure of 6 bar, a velocity of 300 m/s, internal energy of 2000 kJ/kg and specific volume 0.4 m^3/kg. It leaves the system at a pressure of 0.1 MPa, a velocity of 150 m/s, the internal energy 1600 kJ/kg and specific volume 1.2 m^3/kg . The inlet is 10 m above the outlet. During its passage through the system the substance has a work transfer of 3 MW to the surroundings. Determine the heat transfer in kJ/s, stating whether it is from or to the system.

12. (a) A reversible heat engine operates between reservoirs at temperature of 873 K and 313 K. The engine drives a reversible refrigerator which operates between reservoirs at temperature of 313 K and 253 K. The heat transfer to the heat engine is 2 MJ and the net-work output from the combined engine-refrigerator plant is 360 kJ. Evaluate the heat transfer to the refrigerant and the net heat transfer to the reservoir at 313 K.

Or

(b) Consider 1 kg of ice at –12 °C as a system. It is exposed to surroundings at 20 °C. The ice melts to water ultimately coming to equilibrium with the surroundings. Calculate the entropy change of the system, the surroundings and the universe. Specific heat of ice and water are 2.2 kJ/kgK and 4.2 kJ/kgK respectively and the latent heat of fusion of ice is 334 kJ/kg.

13. (a) A reheat cycle has the following data:

Steam at boiler outlet = 30 bar and 450 °C.

Reheated at 2.5 bar and 450 °C.

Steam pressure at the exit of turbine = 0.04 bar.

The first expansion takes place till the steam is dry saturated and then reheat is carried out. Neglect the pump work and determine the efficiency of reheat cycle. Assume the turbine efficiency is 100%.

Or

(b) (i) Air flows through an adiabatic compressor at 2 kg/s. The inlet conditions are 100 kPa and 310 K, and the exit conditions are 700 kPa and 560 K. Consider T_0 to be 298 K. Determine the change of availability and the irreversibility. (10)

(ii) Write short notes on the principle of increase in entropy. (3)

14. (a) Steam at 2 MPa and 350 °C expands in a turbine isentropically to the condenser pressure of 0.075 bar. Determine the ideal work output of the turbine per kg of steam, efficiency and the steam rate.

Or

(b) (i) Ice at -30 °C and atmospheric pressure is heated in an open vessel. With the help of phase change diagram, explain the process of conversion from one kg of ice to superheated steam on temperature versus heat transfer plane. Also describe the process parameters involved in it. (8)

(ii) With the help of T-s diagram, briefly discuss about the process of formation of steam. (5)

15. (a) (i) Derive the expression for Clausius Claperyon equation and mention its significance. (6)

(ii) An ideal gas mixture at 21 °C consists of 0.1 kg of CO_2 and 0.6 kg of N_2. Compute the equivalent molecular weight and gas constant of the mixture. Take molecular weight of CO_2 and N_2 as 44 and 28 respectively. (7)

Or

(b) Derive the Maxwell's relations.

PART C — (1 × 15 = 15 marks)

16. (a) A regenerative cycle has steam supplied at 30 bar, 300 °C in first stage. A steam fraction is bled out at 4 bar for feed heating. The feed heater drains are pumped into feed line downstream of heater at the same temperature as the bled steam. The steam expansion may be considered isentropic throughout. Condenser works at 0.15 bar. Determine mass of steam bled per kg of steam generated and thermal efficiency.

Or

(b) A certain gas of volume 0.4 m^3, pressure of 4.5 bar and temperature of 130 °C is heated in a container to 9 bar when the volume remains constant. Calculate (i) temperature at the end of the process (ii) the heat transfer, (iii) change in internal energy (iv) work done by the gas (v) the change in enthalpy and (vi) mass of the gas. Assume $C_p = 1.005$ kJ/kgK and $C_v = 0.71$ kJ/kgK.

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