Ref. No.: Ex/CE/ES/B/ME/T/221/2024

B. E. CIVIL ENGINEERING SECOND YEAR SECOND SEMESTER EXAMINATION 2024

Subject: THERMODYNAMICS & HEAT POWER

Time: 3 hours **Full Marks: 100**

Use of Steam Table is permissible.
All symbols carry their usual meanings. Note assumptions, if required.
Answer any FIVE questions.

Q.1 Answer any TEN questions. 2×10=20

(a) Differentiate between a path and a process.
(b) Does a specific extensive property refer to an intensive property? Explain.
(c) In case of an ideal gas, show that $C_P - C_v = R$.
(d) Show that an adiabatic reversible process follows $Pv^Y = C$ relation.
(e) What is PMM1?
(f) Define dryness fraction.
(g) Define critical and triple point of water.
(h) Calculate the maximum thermal efficiency of a heat engine operates between 27°C and 327°C.
(i) What is PMM2?
(j) Write the expressions for efficiency of a reversible heat engine and COP of a reversible heat pump working between a high temperature reservoir at temperature T_H and low temperature reservoir at temperature T_L
(k) State any one corollary of the Second Law of Thermodynamics
(l) Show Carnot cycle on T-s plane.

Q.2 (a) (i) Plot a constant pressure line on T-v plane for a pure substance labelling all the states from subcooled liquid to superheated vapour. (2+2)
(ii) Plot a constant temperature line on T-v plane for a pure substance labelling all the states from subcooled liquid to superheated vapour.

(b) Define degree of sub-cooling and superheating of a pure substance. Show them on T-v plane. (2+2)

(c) A 0.5 m^3 rigid vessel initially contains a wet steam at 100°C. The steam is heated until it reaches to its critical state. Plot the process on P-v plane. Determine mass and volume of the liquid water in the wet steam at its initial state. Then, find the amount of heat supplied to the system. Use Steam Table. (12)

Q.3 (a) State the 'First Law of Thermodynamics' for a cyclic process. Hence, show that stored/internal energy is a property of system. (2+4)

(b) A fluid is contained in a cylinder by a spring-loaded frictionless piston so that pressure in the fluid is a linear function of its volume as $P = a + bV$ where a and b are constants. The internal energy of the fluid is given as $U = 42 + 3.6PV$ where U is in kJ, P in kPa, and V in m^3. If the fluid changes from an initial state of 190kPa and 0.035m^3 to a final state of 420kPa and 0.075m^3 by supplying heat to the fluid, then find the (i) values of a and b, (ii) change in the internal energy, (iii) work done by the fluid, and (iv) heat transfer to the fluid. (14)

Q.4 (a) State the assumptions in case of steady state condition for the flow of mass and energy through an open system. (2)

(b) Derive a standard expression for the steady state energy equation in case of open system. (10)

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(c) At inlet of an adiabatic nozzle, specific enthalpy and velocity of its moving fluid is 2800 kJ/kg and 50 m/s, respectively. The enthalpy at exit of the nozzle is 2600 kJ/kg. Find velocity of the fluid at exit of the nozzle. State necessary assumptions, if required. Plot the process on T-s plane. (6+2)

Q.5 (a) Establish the Clausius Theorem. Hence, show that entropy is a property of system. (6+4)

(b) Show that the slope of a constant volume process is higher than that of a pressure process. (2)

(c) Calculate change of entropy of a 2kg of air expanding polytropically in a piston-cylinder system from 8bar and 700°C to 1.5bar. Consider the index of expansion as 1.25. Compare it with the case of an isothermal expansion. (8)

Q.6 (a) Find an expression for the thermal efficiency of Otto cycle. (8)

(b) An Otto cycle has a compression ratio of 8, and its compression begins at 27°C and 0.1 MPa. The maximum temperature of the cycle is 1100°C. Plot the cycle on P-v and T-s planes, and find (i) temperature, pressure and specific volume at each node of the cycle, (ii) heat supplied per kg of air, (iii) net work done per kg of air, (iv) cycle efficiency, and (v) mean effective pressure of the cycle. (12)

Q.7 Write short notes on (any FIVE): 4×5=20

(a) Microscopic and macroscopic approaches
(b) System and its classification
(c) Property and its classification
(d) Thermodynamic equilibrium
(e) Zeroth law of thermodynamics
(f) Throttling process: an isenthalpic process
(g) Write statements of the second law of thermodynamics

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