CBCS SCHEME

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17AE/AS33

Third Semester B.E. Degree Examination, June/July 2019
Aerothermodynamics

Time: 3 hrs. Max. Marks: 100

Note:* 1. *Answer any FIVE full questions, choosing ONE full question from each module.
2. Use of thermodynamics data handbook/charts/tables is permitted.

Module-1

1 a. With a neat sketch, explain the working of a thermocouple. **(06 Marks)**

b. With a neat sketch, explain Quasi-static process. **(06 Marks)**

c. The temperature of a fluid is measured with a Celsius thermometer as well as Fahrenheit thermometer. If the numerical reading is same for both thermometers, determine the temperature in degree Celsius and degree Fahrenheit. **(08 Marks)**

OR

2 a. A spherical balloon has an initial diameter of 25 cm and contains air at 1.2 bar. When heated, the diameter increases to 30 cm. During heating, the pressure is found to be proportional to diameter. **(06 Marks)**

b. With a neat PV diagram, derive an expression for work done in isothermal process and polytropic process. **(08 Marks)**

c. A gas is compressed from 0.3 m^3 to 1m^3. The process follows $p = av^{-2}$, where a = 8 kPa/m^2. Calculate work done. **(06 Marks)**

Module-2

3 a. State first law of thermodynamics and explain Joules experiment with a neat sketch. **(06 Marks)**

b. Prove that internal energy is a property of the system. **(06 Marks)**

c. Write the steady flow energy equation for an open system and explain the terms involved in it. Simplify SFEE for the following systems: (i) Steam turbine (ii) Nozzle. **(08 Marks)**

OR

4 a. The properties of a certain fluid are related as follows: U = 196 + 0.718 T and PV = 0.287 (T + 273), U is specific internal energy in kJ/kg, P is pressure in kN/m^2, V is specific volume in m^3/kg. A closed system consisting of 2 kg of this fluid expands in an irreversible adiabatic process related by $PV^{1.2} = C$. The initial conditions are 1 MPa and 200°C and final pressure is 100 kPa. Determine the work transfer and change in internal energy for the process. **(10 Marks)**

b. A vertical cylinder fitted with a frictionless piston, contain gas at pressure 200 kN/m^2. The upper surface of piston is exposed to atmosphere. The gas executes a cycle by undergoing the following process in sequence.

i) With the cylinder insulated, 1.2 kJ of stirring work is done on the gas by a paddle wheel projecting through cylinder wall. As a result, the gas temperature rises and piston moves slowly upwards. The increase in volume is 0.0028 m^3.

ii) With the insulation removed and paddle wheel stationary heat transfer from gas restores gas to original state.

Find work during process (i) and (ii), heat during process (ii). **(10 Marks)**

Module-3

5 a. Using Kelvin Plank statement, show that heat transfer through finite temperature difference is irreversible. **(06 Marks)**

b. State and prove Clausius inequality. What is the significance of Clausius inequality? **(06 Marks)**

c. Two reversible engines A and B are in series. A receives 200 kJ for HTR and 421°C, B rejects heat to sink at 4.4°C. If the work of A is twice of B, determine intermediate temperature, efficiency of A and B, heat rejected to sink **(08 Marks)**

OR

6 a. State the Kelvin Plank and Clausius statements of the second law of thermodynamics and show that the violation of the former results in the violation of the later. **(10 Marks)**

b. A heat pump working on a reversible cycle takes heat form a reservoir at 5°C and delivers heat to HTR at 60°C. The heat pump is driven by a heat engine taking heat from source at 840°C and rejects heat to LTR at 60°C. The engine also drives a machine of 30 KW capacity. If the heat pump extracts 17 kJ/s from LTR at 5°C, find: (i) Rate of heat flow from reservoir at 840°C (ii) Rate of heat rejected to sink at 60°C. **(10 Marks)**

Module-4

7 a. Derive Vander Waal's constants in term of critical properties. **(06 Marks)**

b. A balloon of spherical shape 6m in diameter is filled with hydrogen gas at a pressure of 1 bar absolute and 20°C. At a later time, the pressure of gas is 94% of its original value of pressure at the same temperature.

i) What mass of the original gas must have escaped if the dimensions of the balloon is not changed?

ii) Determine the amount of heat removed to cause the same drop in pressure at constant volume.

Take CV = 10,400 K/kg.K **(06 Marks)**

c. Write Maxwell relations and explain the terms involved. **(08 Marks)**

OR

8 a. Explain the law of corresponding states with a generalized compressibility chart. **(06 Marks)**

b. The volumetric analysis of a gaseous mixture yields the following results CO_2 = 12%, N_2 = 82%, O_2 = 4%, CO = 2%. Determine the analysis on mass basis, the molecular weight and gas constant for the mixture. Assume the ideal gas behavior. **(06 Marks)**

c. Define and explain: (i) Critical point (ii) Triple point (iii) Dryness fraction (iv) Latent heat. **(08 Marks)**

Module-5

9 a. With the help of T-S and P-V diagrams, evaluate an expression for the air standard efficiency of a diesel cycle. **(10 Marks)**

b. A 40 MW steam power plant working on Rankine cycle operates between boiler pressure of 4 MPa and condenser pressure of 10 kPa. The steam leaves the boiler and enters the steam turbine at 400°C. The isentropic efficiency of the steam turbine is 85%. Determine: (i) The cycle efficiency (ii) The quality of steam from the turbine (iii) Steam flow rate in kg per hr. consider pump work. **(10 Marks)**

OR

10 a. Sketch the flow diagram and corresponding T-S diagram of a reheat vapour cycle and evaluate an expression for reheat cycle efficiency. **(10 Marks)**

b. Draw a neat line diagram and T-S diagram for a practical regenerative Rankine cycle with open feed water heater. Also write the energy balance equation. **(10 Marks)**

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