CBCS SCHEME

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15AE33

Third Semester B.E. Degree Examination, July/August 2021
Aerothermodynamics

Time: 3 hrs. Max. Marks: 80

Note:1. ***Answer any FIVE full questions.***
2. ***Use of thermodynamics Data Hand book is permitted.***

Important Note : 1. On completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages.
2. Any revealing of identification, appeal to evaluator and /or equations written eg, 42+8 = 50, will be treated as malpractice.

1 a. With suitable examples define the following :
(i) Intensive and extensive properties.
(ii) Open and closed systems.
(iii) Point and path functions.
(iv) Thermal and thermodynamic equilibrium. **(08 Marks)**

b. Sir Isaac Newton proposed a linear temperature scale known as Newton's scale wherein the ice point and the normal human body temperature were assumed as the two fixed points assigning temperatures of 0° and 12° respectively. If the temperature of the human body on the Fahrenheit scale is 98°F, obtain a relation between Newton's scale and Fahrenheit scale. **(08 Marks)**

2 a. Define work and heat and differentiate between the same. **(06 Marks)**

b. A fluid undergoes the following processes in sequence to complete a cycle :
(i) Heated reversibly at constant pressure of 1.05 bar until it has a volume of 0.02 m^3.
(ii) It is then compressed reversibly according to the law PV = C, to a pressure of 4.2 bar.
(iii) It is then allowed to expand reversibly according to a law $PV^{1.3} = C$
(iv) Finally it is heated back to its initial conditions at constant volume. Sketch this cycle on a P-V diagram.
If the workdone during the constant pressure process is 515 Nm, calculate the network done on or by the cycle. **(10 Marks)**

3 a. State the first law of thermodynamics for a system undergoing a cyclic process. Further deduce that internal energy is a property of the system. **(10 Marks)**

b. In an air compressor the system cycle completed as follows:
(i) 8.2 kNm work as done by the piston on air during compression stroke and 45 kJ of heat was rejected.
(ii) During expansion stroke 10 kNm of work was done by air on the piston. Determine the quantity of heat added to the system. **(06 Marks)**

4 a. Write SFEE (Steady Flow Energy Equation) for an open system and modify it suitably to the following devices:
(i) Turbine
(ii) Blower. **(08 Marks)**

b. A centrifugal pump delivers 60 kg of water per second at an inlet pressure of 10 kPa to an outlet pressure of 400 kPa. If the suction and delivery pipe diameters are respectively 0.2 m and 0.1 m respectively, determine the power required to drive the pump motor. Note that the suction is 2 m below and the delivery is 8 m above the centre line of the pump. **(08 Marks)**

5 a. Discuss the limitations of first law of thermodynamics. With the help of schematic diagrams state and explain the second law of thermodynamics as per Kelvin planck and Clausius. **(10 Marks)**

b. An inventor claims that his petrol engine operating between the temperatures 2000°C and 600°C will produce 0.736 kW-hr consuming 0.15 kg of petrol of 46000 kJ/kg calorific value. Check the validity of his claim. **(06 Marks)**

6 a. Derive Clausius inequality and hence prove that entropy is a property. **(06 Marks)**

b. Define available and unavailable energy. **(04 Marks)**

c. A heat engine receives reversibly 7500 kJ/min from a source at 1000 K. The atmosphere is at 300 K. Assuming that the temperature of the system and source remain constant during heat transfer, find the (i) net change of entropy during heat transfer, (ii) the decrease in available energy after heat transfer. Assume the engine temperature at 500 K. **(06 Marks)**

7 a. Define ideal and real gases. Write any two equations of state you know. **(04 Marks)**

b. With reference to a pure substance define the following. Represent the same on a T-S plot.
(i) Dryness fraction (ii) Sub cooled liquid
(iii) Latent heat (iv) Critical point. **(06 Marks)**

c. The pressure and temperature of a gas is 7 MPa and 150°C respectively. The critical temperature and the pressure of the gas are respectively 4.26 MPa and 370 K. Find the reduced temperature and pressure of the gas. If R = 0.19 kJ/kgK and Z = 0.54. Calculate the specific volume of the gas. What would be the specific volume if the gas were to be considered as perfect? **(06 Marks)**

8 a. Show that for an ideal gas a reversible adiabatic process is represented by $PV^{\gamma} = \text{constant}$, where P is the pressure, V is the volume, γ is the ratio of specific heats. **(06 Marks)**

b. What is the significance of Maxwell's relations? Write down any two sets of Maxwell's relations. **(04 Marks)**

c. Compute from Vander Waal's equation, the pressure exerted by 1 kg of CO_2 at 100°C, if the specific volume is 3 m^3/kg. Also compare the results obtained, if CO_2 is treated as an ideal gas. Take $a = 362.85 \times 10^3$, R = 8314.3 J/kg.K, b = 0.0423, where a and b are in consistent units. **(06 Marks)**

9 a. Show that the air standard efficiency of an engine working on an ideal Otto cycle depends only on the compression ratio and not on the heat supplied to it. **(08 Marks)**

b. In an air standard diesel cycle, the compression ratio is 15 and the fluid properties at the beginning of compression is 100 kPa and 27°C. If the peak temperature is 1327°C, determine
(i) Percentage of stroke at which cut-off takes place (ii) Cycle efficiency
(iii) Workdone /kg of air. **(08 Marks)**

10 a. With the help of a T-S diagram, for the same temperature limits, compare Rankine and Carnot cycles for (i) Efficiency (ii) Specific work output (iii) Vapour compression. **(06 Marks)**

b. A steam power plant incorporates an ideal reheat cycle to improve the existing efficiency. Steam at 30 bar and 250°C is supplied at the HP turbine inlet and expands till it is dry saturated at 3 bar. Now the steam is taken to the reheater and its temperature is again increased to 250°C at constant pressure reheating process. The reheated steam expands in the LP turbine to a condenser pressure of 0.04 bar. Determine the cycle efficiency. **(10 Marks)**

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