

First Semester M. E. (Mech. Engg.) (TE) Examination

ADVANCED THERMODYNAMICS

1 MTE 2

P. Pages : 4

Time : Three Hours]

[Max. Marks : 80

- Note :** (1) Separate answer book must be used for each Section in the subject Geology, Engineering material of civil branch and Separate answer – book must be used for Section A and B in Pharmacy and Cosmetic Tech.
- (2) Answer any **three** questions from Section A and any **three** questions from Section B.
- (3) Assume suitable data wherever necessary.
- (4) Diagrams and Chemical equations should be given wherever necessary.
- (5) Use of slide rule, logarithmic tables, Steam tables, Mollier's Chart, Drawing instrument, Thermodynamic table for moist air, Psychrometric Charts and Refrigeration charts is permitted.

SECTION A

1. (a) Steam enters a turbine at a pressure of 100 bar and temp. of 400°C . At the exit of the turbine the pressure is 1 bar and the entropy is 0.6 J / g.k greater than that at inlet. The process is adiabatic. Find the work done by the steam in J/g . What is the mass flow rate of steam required to produce a power output of 1 KW ? 7
- (b) Derive the expression for irreversibility or energy loss in a process executed by :
 - (1) closed system (2) steady flow system. 6
2. (a) An ideal gas of molecular weight 30 and $\gamma = 1.3$ occupies volume of 1.5 m^3 at 100 kPa and 77°C . The gas is compressed according to the law $pu^{1.25} = \text{const.}$ to a pressure of 3 MPa. Calculate volume and temperature at the end of compression and find work done, heat transferred and change of entropy. 8
- (b) What do you understand by lost work ? Give the expression for the entropy generation rate for a control volume of a steady flow system. 5

3. (a) A reversible engine works between three thermal reservoirs A, B and C. The engine absorbs equal amount of heat from thermal reservoirs A and B kept at temp. T_A and T_B respectively and rejects heat to thermal reservoir C kept at temp. T_C . The efficiency of engine is α times the efficiency of reversible engine, which works between the two reservoirs A and C. Prove that

$$\frac{T_A}{T_B} = (2\alpha - 1) + 2(1 - \alpha) \frac{T_A}{T_C} \quad 8$$

- (b) Show that for Van der Waals gas.

$$C_p - C_v = \frac{R}{1 - \frac{2a(v-b)^2}{v \cdot R \cdot T}} \quad 5$$

4. (a) Derive the Stefan – Boltzman law by using thermodynamics relations. 4

- (b) A 5-kg iron block initially at 350°C is quenched in an insulated tank that contains 100 kg of water at 30°C . Assume the water that vaporizes during process is condenses back in the tank and the surroundings are 20°C and 100 kPa

Determine

- (a) Final equilibrium temp.
(b) The exergy of combined system at initial and final state
(c) The wasted work potential during this process.

Assume – $C_i = 0.45 \text{ KJ / kg. K.}$

$C_w = 4.18 \text{ KJ / kg. K.}$

10

5. (a) Prove that thermal efficiency of Carnot cycle is function of temp. of source and sink and independent of working substance. 7

- (b) 0.1 m^3 of hydrogen initially at 1.2 MPa 200°C undergoes a reversible isothermal expansion to 0.1 MPa. Find

- (a) Heat transferred during the process
(b) Entropy change of the gas. 6

SECTION B

6. (a) Starting from general expression for the second law for control volume, show that for unsteady state unsteady flow process

$$(m_2 S_2 - m_1 S_1)_{cv} + \sum Me Se - \sum mi si \geq \int_1^2 \left(\frac{Q_{cv}}{T} \right) dt \quad 6$$

- (b) Explain thermochemical energy and chemical energy and define second law efficiency of reactive system. 7

7. (a) A quantity of steam at a pressure of 2.1 MN/m^2 and 0.9 dry occupies a volume of 0.427 m^3 , it expands according to law $PV^{1.25} = \text{const.}$ to a pressure of 0.7 MN/m^2 . Determine work transfer and heat exchange between system and surrounding in kJ. 7

- (b) A quantity of mixture of ideal gas has a pressure of 700 kN/m^2 and it occupies a volume of 0.014 m^3 at a temperature of 150°C . The gas expands isothermally to a volume of 0.084 m^3 . Determine change in entropy. 7

8. (a) A gas mixture at 100 KPa , 25°C has a mass analysis of 18% H_2 , 32% N_2 and 50% O_2 . Determine,

(i) The partial pressure of components

(ii) Constant pressure specific heat. 6

- (b) Balance the chemical equation for combustion of octane C_8H_{18} with theoretical air amount. Also find theoretical Air - fuel ratio. 7

9. (a) What is importance of adiabatic flame temperature? Why is actual temperature of real combustion process much less than adiabatic flame temperature? 6

- (b) A simple steam turbine power plant Rankine cycle operates between condenser pressure of 0.1 bar and boiler pressure of 3, 4, 6, 8, 10 and 12 MPa. Analyse the effect of varying boiler pressure on cycle efficiency and quality of steam at outlet from turbine. Assume saturated steam at the boiler outlet for each pressure. 7

10. (a) How the second Law efficiency of ideal Rankine cycle can be improved ?
6
- (b) A reversible heat engine operates on a Carnot cycle with upper temperature limit of 400°C and has thermal efficiency of 55%. The volume ratio of the expansion of isothermal process is 2.8. Determine overall volume expansion ratio (Take $C_p / C_v = 1.4$)
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