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JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
M.Tech I Semester Examinations, June/July - 2019
ADVANCED THERMODYNAMICS
(Thermal Engineering)

Time: 3hrs **Max.Marks:75**

Note: This question paper contains two parts A and B.
Part A is compulsory which carries 25 marks. Answer all questions in Part A. Part B consists of 5 Units. Answer any one full question from each unit. Each question carries 10 marks and may have a, b, c as sub questions.

PART - A

5 × 5 Marks = 25

1.a) An ideal gas undergoes a reversible, steady-flow process in which pressure and volume are related by the polytropic equation Pv^n= constant. Neglecting the changes in kinetic and potential energies of the flow and assuming constant specific heats, (i) obtain the expression for the heat transfer per unit mass flow for the process and (ii) evaluate this expression for the special case where n = k = cp/cv. [5]

b) What is an ideal solution? Comment on the volume change, enthalpy change, entropy change, and chemical potential change during the formation of ideal and non ideal solutions. [5]

c) A certain natural gas has the following volumetric analysis: 65 percent CH_4, 8 percent H_2, 18 percent N_2, 3 percent O_2, and 6 percent CO_2. This gas is now burned completely with the stoichiometric amount of dry air. What is the air–fuel ratio for this combustion process? [5]

d) What is a binary power cycle? What is the difference between the binary vapor power cycle and the combined gas–steam power cycle? [5]

e) What is thermoelectric power of a thermocouple? Show that it is given by the difference of the entropy transport parameters of the two wires. [5]

PART - B

5 × 10 Marks = 50

2. In order to cool 1 ton of water at 20^0C in an insulated tank, a person pours 80 kg of ice at 25^0C into the water. Determine
i) The final equilibrium temperature in the tank and
ii) The energy destroyed during this process. The melting temperature and the heat of fusion of ice at atmospheric pressure are 0^0C and 333.7 kJ/kg respectively. Take $T_0 = 20^0$C. [3+7]

OR

3. In a steam boiler, hot gases from a fire transfer heat to water which vaporizes at constant temperature. In a certain case, the gases are cooled from 1150^0C to 600^0C while the water evaporates at 250^0C. The specific heat of gases is 1.005 kJ/kg-K, and the latent heat of water at 250^0C, is 1860 kJ/kg. All the heat transferred from the gases goes to the water. How much does the total entropy of the combined system of gas and water increase as a result of the irreversible heat transfer? Obtain the result on the basis of 1 kg of water evaporated. If the temperature of the surrounding is 40^0C, find the increase in unavailable energy due to irreversible heat transfer. [10]

4. Saturated air at 2^0C is required to be supplied to a room where the temperature must be held at 20^0C with a relative humidity of 50%. The air is heated and then water at 10^0C is sprayed in to give the required humidity. Determine the temperature to which the air must be heated and the mass of spray water required per m^3 air at room conditions. Assume that the total pressure is constant at 1.013 bar and neglect the fan power. [10]

OR

5. Cooling water enters a cooling tower at a rate of 1000 kg/hr and 70^0C. Water is pumped from the base of the tower at 25^0C and some make-up water is added afterwards. Air enters the tower at 15^0C, 50% RH, 1.013 bar, and is drawn from the tower at saturated at 35^0C, 1 bar. Calculate the flow rate of the dry air in kg/h and the make-up water required per hour. [10]

6.a) Propanol alcohol (C_3H_7OH) is burned with 50% excess air. Write the balanced reaction equation for complete combustion and determine the air-to-fuel ratio.

b) Octane (C_8H_{18}) is burned with dry air. The volumetric analysis of the products on a dry basis is 9.21 percent CO_2, 0.61 percent CO, 7.06 percent O_2, and 83.12 percent N_2. Determine (i) the air-fuel ratio and (ii) the percentage of theoretical air used. [4+6]

OR

7.a) How is the heating value of a fuel related to the enthalpy of combustion of that fuel?

b) Liquid octane (C_8H_{18}) enters the combustion chamber of a gas turbine steadily at 1 atm and 25^0C, and it is burned with air that enters the combustion chamber at the same state. Determine the adiabatic flame temperature for i) complete combustion with 100 percent theoretical air, ii) complete combustion with 400 percent theoretical air, and iii) incomplete combustion (some CO in the products) with 90 percent theoretical air. [2+8]

8. An air-conditioner operates on the vapor- compression refrigeration cycle with refrigerant-134a as the refrigerant. The air conditioner is used to keep a space at 218^0C while rejecting the waste heat to the ambient air at 378^0C. The refrigerant enters the compressor at 180 kPa superheated by 2.78^0C at a rate of 0.06 kg/sand leaves the compressor at 1200 kPa and 608^0C. R-134a is subcooled by 6.38^0C at the exit of the condenser. Determine a) the rate of cooling provided to the space, in Btu/h, and the COP, b) the isentropic efficiency and the exergy efficiency of the compressor, c) the exergy destruction in each component of the cycle and the total exergy destruction in the cycle, and d) the minimum power input and the second-law efficiency of the cycle. [10]

OR

9. A solar collector system delivers heat to a powerplant. It is well known that the thermal collection efficiency η_{sc} of a solar collector diminishes with increasing solar collection output temperature T_H, or η_{sc} = $[A-BT_H]$ where A and B are known constants. The thermal efficiency of the power plant η_{th} is a fixed fraction of the Carnot thermal efficiency, such that η_{th} = $F(1-T_L/T_H)$ here F is a known constant assumed here independent of temperatures and T_L is the condenser temperature, also constant for this problem. Here, the solar collection temperature T_H is also taken to be the source temperature for the power plant.

a) At what temperature T_H should the solar collector be operated to obtain the maximum overall system efficiency?

b) Develop an expression for the maximum overall system efficiency. [5+5]

10. Derive expressions for voltage generated, the temperature drop and the thermal efficiency for a MHD generator. [10]

OR

11.a) Derive the theoretical efficiency of Fuel cell.

b) Explain the effect of reactant flow rates and reactants humidity on cell performance. [5+5]

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