Seat No.: ________ Enrolment No.______________

GUJARAT TECHNOLOGICAL UNIVERSITY

B. E. - SEMESTER – IV • EXAMINATION – WINTER 2012

Subject code: 141903 **Date: 27/12/2012**

Subject Name: Engineering Thermodynamics

Time: 02.30 pm - 05.00 pm **Total Marks: 70**

Instructions:

1. **Attempt any five questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**
4. **Use of Steam tables and Molier diagram is permitted**

Q.1 **(a)** (1) Explain different types of systems with suitable examples. **07**
(2) Discuss the concept of thermodynamic equilibrium.
(3) Distinguish between Intensive and extensive properties.

(b) Write continuity equation. Derive the general steady flow energy equation. Making suitable assumptions reduce the same for turbine, nozzle and steam condenser. **07**

Q.2 **(a)** (1) A turbine operating under steady flow conditions receives steam at a velocity of 50 m/s and elevation of 5 m and a specific enthalpy of 2700 KJ/kg. The steam leaves the turbine at a velocity of 83.3 m/s, an elevation of 1.5 m and a specific enthalpy of 2250 kJ/kg. Heat losses from the turbine to the surroundings amount to 1.41 kJ/hr. Determine the mass flow rate of steam required in kg/hr for output power of 360 kW. **07**

(2) A well-insulated rigid tank of 1 m^3 is attached to a large line containing pressurized oxygen. A valve is opened allowing the oxygen to enter the tank. The state of oxygen in the line is 2 MPa and 300°C. The valve remains open till the oxygen inside the tank reaches pressure equilibrium with the oxygen in the line. Determine the temperature of oxygen inside the tank at the end of process. Initial pressure and temperature of oxygen in the tank is 1 bar and 300K. Take R = 0.259 kJ/kg K and $\gamma = 1.395$

(b) Explain Kelvin-Plank and Clausius statements of second law and show that violation of Kelvin-Plank statement leads to violation of Clausius statement. **07**

OR

(b) Show that efficiency of all reversible engines operating between two constant temperature heat reservoirs is the same. **07**

Q.3 **(a)** Two Carnot engine A & B are connected in series between two thermal reservoirs maintained at 2000K and 300K. Engine A receives 1680 kJ of heat from the high temperature reservoir and reject heat to the Carnot engine B. Engine B takes in heat rejected by A and rejects heat to the low temperature reservoir. If engines A & B have equal thermal efficiencies, determine (a) the heat rejected by engine B (b) the temperature at which heat is rejected by engine A, (c) work done by engine A & B. If engine A & B delivers equal work, determine (d) the amount of heat taken by engine B, and (e) efficiencies of engine A & B. **07**

(b) (1) Show that through one point there can pass only one reversible adiabatic. **07**
(2) Derive Clausius' inequality from fundamental.

OR

Q.3 **(a)** Derive equation for exergy of finite heat capacity source at temperature T. Also differentiate between available and unavailable energy. **07**

(b) (1) In a boiler, water evaporates at 200°C. The hot gases which transfer the heat to the boiler are cooled from 1000°C to 500°C. Determine the total entropy increase of combined system of gas and water and the increase in unavailable energy. T_0 = 30°C. Take c_{pg} = 1 kJ/kg K. **07**

(2) 2 kg of water at 97°C is mixed with 3 kg of water at 17°C in an isolated system. Calculate the change in entropy due to the mixing process.

Q.4 **(a)** (1) Explain the effect of boiler pressure on performance of Rankine cycle. **07**

(2) In a simple Rankine cycle condition of steam at inlet to turbine is 100 bar and 550^{o}C. If dryness fraction at exit to turbine is to be restricted to 0.9 calculate the ideal cycle efficiency and steam rate.

(b) (1) Prove that $c_p - c_v = \dfrac{Tv\beta^2}{k}$ **07**

(2) Write short note on Joule Thomson coefficient.

OR

Q.4 **(a)** The compression ratio of air-standard Dual cycle is 12 and the maximum pressure in the cycle is limited to 70 bar. The pressure and temperature of cycle at the beginning of compression process are 1 bar and 27°C. Heat is added during constant pressure process up to 3% of the stroke. Assume diameter as 25 cm and stroke as 30 cm determine (1) pressure and temperature at each point in the cycle (2) Thermal efficiency (3) The mean effective pressure. **07**

Q.4 **(b)** (1) State the Maxwell's relations and derive them. What is their importance? **07**

(2) Verify cyclic relation for an ideal gas.

Q.5 **(a)** From the Vander Waal's equation derive the following equation for law of corresponding states. **07**

$$\left(p_r + \frac{3}{v_r^2}\right)(3v_r - 1) = 8T_r$$

Also explain reduced properties and generalized compressibility chart.

(b) Explain construction of Bomb calorimeter. How calorific value of a fuel can be obtained using the same? What are the various corrections applied for the calculation of the calorific value using the calorimeter? **07**

OR

Q.5 **(a)** State Dalton's law of partial pressure. How is partial pressure of in a gas mixture related to the mole fraction? How are the characteristic gas constant, molecular weight and specific heats of a gas mixture computed? **07**

(b) (1) Why excess air is used for burning of fuel? Explain enthalpy of formation and adiabatic flame temperature. **07**

(2) The analysis by weight of a gaseous mixture is CO_2 = 15.98%, CO = 0.93%, O_2 = 7.57 % & N_2 = 75.52 %. Convert this analysis into volumetric analysis.

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