Seat No.: _____ Enrolment No.

GUJARAT TECHNOLOGICAL UNIVERSITY

BE - SEMESTER– III (New) EXAMINATION – WINTER 2019

Subject Code: 2131905 **Date: 3/12/2019**

Subject Name: Engineering Thermodynamics

Time: 02:30 PM TO 05:00 PM **Total Marks: 70**

Instructions:

1. **Attempt all questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**
4. **Use of Steamtable and Moiler chart is allowed**

Q.1 **(a)** Draw p-T diagram of pure substance which represents the all three phases. **03**

(b) For an isothermal steady flow and non-flow processes. Prove that, **04**

$\int_1^2 p\,dv = -\int_1^2 v\,dp$. Also state the assumptions made.

(c) A mixture of ideal gases consists of 5 kg of nitrogen and 7 kg of carbon dioxide at a pressure of 3 bar and temperature of 23 ^{0}C. Determine (i) the mole fraction of each constituent, (ii) the equivalent molecular weight of the mixture, (iii) the equivalent gas constant of the mixture, (iv) the partial pressures and partial volumes, (v) the colume and density of the mixture and (vi) the Cp and Cv of the mixture. **07**

If the mixture is heated at constant volume to 40 ^{0}C, calculate the changes in internal energy, enthalpy and entropy of the mixture. Calculate the changes in internal energy, enthalpy and entropy of the mixture if the heating is done at constant pressure. Take γ for CO_2 and N_2 to be 1.286 and 1.4 respectively.

Q.2 **(a)** Prove that ΔE = Constant for isolated system. **03**

(b) Prove that two reversible adiabatic paths cannot intersect each other. **04**

(c) A reversible Carnot cycle operates at either a refrigerator or heat pump. In either case, the power output is 20.8 kW. Calculate the quantity of heat extracted from the cold body for either type of machine. In both case 3500 kJ/min heat is delivered by the machine. In case of the refrigerator the heat is transferred to the surroundings while in case of heat pump, the space is to be heated. What is their respective co-efficient of performances? If the temperature of the cold body is 0 ^{0}C for the refrigerator and 5 ^{0}C for the heat pump what will be respective temperatures of surrounding for refrigerator and heated space for heat pump? What reduction in heat rejection temperature would be achieved by doubling the COP for same cold body temperature? **07**

OR

(c) Three Carnot engines E_1, E_2, E_3 operates between temperatures 1000 K and 300 K. Make calculations for the intermediate temperatures if the work produced by the engines are in the ratio of 4:3:2. **07**

Q.3 **(a)** Derive an expression for availability of steady flow open system. **03**

(b) Derive an expression for net workdone by Brayton cycle gas turbine power plant. Also state the condition for maximum workdone. **04**

(c) 10 kg of steam at pressure 8 bar and temperature 350 ^{0}C expands reversibly to a pressure 1 bar with dryness factor 0.95. The expression of the steam assumed to be straight line on T-S diagram. Determine, **07**

(i) Change of entropy during process,

(ii) Heat transfer during process and

(iii)Work transfer during process.

OR

Q.3 **(a)** What are the characteristics of entropy? Prove that entropy is a property of a system. **03**

(b) Explain in brief, with rough graphs, the effect of regenerative, simple and complete gas turbine cycle on specific fuel consumption for all values of compression ratio. **04**

(c) 30 kg of water at 98 ^{0}C mix with 40 kg of water at 38 ^{0}C, at constant pressure. The temperature of surroundings is 18 ^{0}C. The specific heat of water is 4.2 kJ/kg K. Calculate (i) change of entropy of water, (ii) availability of water and (iii) irreversibility. **07**

Q.4 **(a)** Derive equation for maximum work obtainable from two infinite bodies at temperature T_1 and T_2. **03**

(b) Explain the effect of regeneration on steam cycle output and efficiency. **04**

(c) A gas turbine plant draws in atmospheric air at 1 bar and 27 ^{0}C. The maximum pressure and temperature of cycle are 9 bar and 1200 ^{0}C respectively. A two-stage compressor is provided with perfect intercooling. Gases are reheated to 1200 ^{0}C in the perfect reheater after H.P. turbine and then expanded in L.P. turbine. Assuming ideal compression, expansion, regeneration and neglecting the mass of fuel, calculate thermal efficiency of cycle. **07**

Repeat the above example without neglecting the mass of fuel and assuming compressor isentropic efficiency is 82 %, turbine isentropic efficiency is 86 %, effectiveness of regenerator is 0.8, calorific value of the fuel is 42 MJ/kg and combustion efficiency is 92 %.

OR

Q.4 **(a)** What is irreversibility? State various types of irreversibility and explain them. **03**

(b) With suitable diagram explain the principle of regenerative feed heating. **04**

(c) A closed cycle gas turbine plant has as two stage of compression and expansion. The pressure and temperature at the inlet of the first stage compressor are 1 bar and 300 K. The maximum cycle temperature and pressure are 1000 K and 6 bar. A perfect intercooler is used between the two stages of compressor. The gases are reheated in reheater upto 1000 K. The regenerator is used to heat the air before entering combustion chamber. Isentropic efficiency of both compressor and turbine is 0.8. the effectiveness of regenerator is 0.68. calculate thermal efficiency of plant. Take γ = 1.4 and Cp = 1.05 kJ/kg K. Also, find mass of air circulated if power developed by plant is 400 kW. **07**

Q.5 **(a)** What is the importance of Carnot cycle? State the processes of this cycle. **03**

(b) Draw the schematic diagram of a simple gas turbine cycle with intercooling, regeneration and reheating. Also draw T-s diagram of the cycle. **04**

(c) A steam turbine is divided in two sections H.P. and L.P. with a reheater interposed in between the two sections. The steam on its way to the turbine at 40 bar and 500 ^{0}C passes through a reheater where it gives up heat at constant pressure to heat the steam flowing from the H.P. to the L.P. section of turbine. The steam then enters the H.P. turbine section at 40 bar and 400 ^{0}C. The steam leaves the H.P. turbine section at 8 bar and the L.P. turbine at 0.05 bar. Determine the steam condition at entrance to the L.P. section and the thermal efficiency of the plant assuming no loss of pressure between the two sections of the turbine and an internal efficiency of 85 % for both the section. **07**

OR

Q.5 **(a)** State the assumptions made for analysis of air standard cycles. **03**

(b) When does the reheating of steam become necessary? Explain the effect of reheat on cycle output and efficiency. **04**

(c) A steam turbine plant equipped with regenerative feed heaters operate under the following conditions: **07**

Initial steam pressure = 30 bar; Initial steam temperature = 400 ^{0}C; Steam pressure in first heater = 7 bar; Steam pressure in second heater = 2 bar; Exhaust pressure = 0.1 bar; Condensate temperature = 40 ^{0}C; Feed temperature after second heater = 102 ^{0}C; Feed temperature after first heater = 170 ^{0}C. The bled steam is condensed in the feed water heater and there is no cooling of the condensate. The drains from the first heater are passed through a steam trap in the second heater and the combined drain from the second heater are pumped by a drain pump into the feed pipe after the second heater. If the internal power developed by the turbine is 13000 kW, find the required

capacity of heater drain pump. The efficiency ratio of the turbine is 0.85 and the condition curve may be assumed to be a straight line.

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