Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

ME – SEMESTER I (OLD) – • EXAMINATION – SUMMER 2016

Subject Code: 713904N Date:21/05/2016

Subject Name: Advanced Thermal Engineering (Mechanical Group)

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 Steam table and property table is permitted.**

Q.1 **(a)** Derive the equation of availability in case of non-flow system. **07**

(b) Derive the equation of velocity, mass flow rate and heat flux in case of laminar film condensation on a vertical plate. **07**

Q.2 **(a)** Derive General heat conduction equation in Cylindrical co-ordinates. Reduce the equation for steady state uni-direction heat flow in radial direction with no internal heat generation, **07**

(b) A centrifugal compressor sucks 30 kg/min air at 1.013bar and 18^0C and compressed adiabatically to 2.5bar and 110^0C. The surrounding temperature is 18^0C. Calculate: (i) Minimum work required (ii) Actual work required (iii) irreversibility (iv) Effectiveness **07**

OR

(b) The temperature on the two surfaces of a 25 mm thick steel plate (k = 48W/m ^{0}C) having a uniform volumetric heat generation of 30 x 10^6 W/m^3, are 180^0C and 120^0C. Neglecting the end effects, determine (i) the temperature distribution across the plate (ii) the value and position of the max. temperature (iii) the flow of heat from each surface of the plate **07**

Q.3 **(a)** Using Gibbs relations derive Maxwell relations. **07**

(b) A 12mm diameter M.S sphere (k = 42.5 W/m ^{0}C) is exposed to cooling airflow at 27^0C resulting in the convective co-efficient h = 114W/m^2 ^{0}C. Determine (i) time required to cool the sphere from 540^0C to 95^0C (ii) instantaneous heat transfer rate 2 minutes after the start of cooling (iii) total energy transfer from the sphere during the first 2 minutes. For M.S. take ρ = 7850 kg/m^3, Cp = 475 J/kg ^{0}C and α = 0.043 m^2/h **07**

OR

Q.3 **(a)** Give a short note on reactive mixtures. **07**

(b) Air enters a compressor at 1 bar, 30^0C, which is also the state of the environment. It leaves at 3.5 bar, 141^0C and 90m/s. Neglecting inlet velocity and PE effect, determine: (i) whether the compression is adiabatic or polytropic (ii) if non adiabatic than polytropic index (iii) the isothermal efficiency (iv) the minimum work input and irreversibility (v) the second law efficiency. Take Cp = 1.0035 kJ/kgK **07**

Q.4 **(a)** Explain the concept of boiling. Differentiate between pool boiling and flow boiling. **07**

(b) A vertical tube of 60 mm outside diameter and 1.2m long is exposed to steam at atmospheric pressure. The outer surface of the tube is maintained at a temperature of 50^0C by circulating cold water through the tube, Calculate the rate of heat transfer to the coolant and rate of condensation of steam. State **07**

whether the flow is laminar or not.

OR

Q.4 **(a)** Derive the expression for NTU for the parallel flow heat exchangers. **07**

(b) A copper pan of 350mm diameter contains water and its bottom surface is maintained at 115^0C by an electric heater. Calculate the power required to boil water in this pan and the rate at which water evaporates from the pan due to the boiling process. Also make calculations for the heat flux for these conditions. Surface fluid constant for water-copper combination is 0.013. **07**

Q.5 **(a)** Write a short note on Gas radiation. **07**

(b) A thermocouple used to measure temperature of gas flowing duct records 280^0C. If emissivity of junction is 0.4 and film co-efficient of heat transfer is 150 W/m^{2}K, find: (i) true gas temperature (ii) what should be the emissivity of junction in order to reduce the temperature error by 30%. The temperature of duct wall is 140^0C. **07**

OR

Q.5 **(a)** Write a short note on compact heat exchangers. **07**

(b) A counter flow concentric tube heat exchanger is used to cool the oil (Cp – 2.18 KJ/kgK) which flows through the tube at 0.19 kg/s and coolant water flows through the annulus at rate of 0.15kg/s (C_p=4.187 KJ/kgK). The oil enters the cooler at 152^0C and leaves at 72^0C while coolant enters at 12^0C. How long the tube must be made to perform this duty if heat transfer co-efficient from oil to tube surface is 2250 W/m^{2}K and from tube surface to water is 5650 W/m^{2}K? The tube has mean diameter of 12.5mm. **07**

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