Seat No.: _____ *Enrolment No._____*

GUJARAT TECHNOLOGICAL UNIVERSITY

M.E Sem-I Regular Examination January / February 2011

Subject code: 711006N

Subject Name: Cryogenic Heat Exchanger

Date: 03 /02 /2011 **Time: 02.30 pm – 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.**

Q.1 **(a)** Consider transient heat conduction in plane wall whose left surface (node 0) is maintain at constant temperature while the right node (node 6) is subjected to convection heat transfer with air having convective heat transfer co-efficient h W/m ^{0}C. Consider uniform heat generation throughout the material (thermal conductivity k w/mK) at the rate of q w/m^3. Express the explicit finite difference formulation of the boundary node 0 & 6 and internal node 3. **07**

(b) With usual notation derive the average heat transfer coefficient (h) for laminar film condensation on vertical plate. **07**

Q.2 **(a)** Explain the finite element philosophy to solve two-dimensional steady state heat conduction problems. **07**

(b) Explain step by step design methodology for shell-tube heat exchanger with NTU-effectiveness approach **07**

OR

(b) Discuss construction, working and design aspects of a Plate-fin type heat exchanger. **07**

Q.3 **(a)** Determine the heat transfer coefficient and pressure drop per unit length for nitrogen gas flowing inside a straight circular tube having an inside diameter of 20 m. The nitrogen gas is at a bulk temperature of 95 K and the tube wall has a temperature of 1105 K. The mass flow rate of nitrogen is 40 g/s and the gas pressure is 140 kPa. **07**

(b) Discuss the different boiling regime. **07**

OR

Q.3 **(a)** A regenerator is constructed of 1.5 mm diameter metal enclosed in a tube having an inside diameter of 40 mm. The porosity of matrix is 0.40 and the heating and cooling periods are equal at 2 seconds. The fluid flowing through the regenerator is gaseous helium at average temperature of 190 K and average pressure of 0.41 mPa. The mass flow rate of helium during the heating and cooling periods is equal to 35 g/s. Determine the required length of the regenerator if an effectiveness of 95% is desired. Consider density of regenerator metal 7800 kg/m^3 and specific heat 840 kJ/gK. **07**

(b) What are TEMA standards? Discuss any three useful TEMA configurations for heat exchangers. **07**

Q.4 **(a)** A single shell pass, four tube counter flow heat exchanger is used as an economizer on a steam generator. Flue gases (Cp=1.06 kJ/kg K)enter the exchanger at 250^0C and leaves at 150^0C with a flow rate of 0.5 kg/s. The feed water enters at 125^0C at the rate of 0.35 kg/s. Determine NTU and effectiveness of heat exchanger. **07**

(b) State and explain Lockhout Mantinelli correlation of two phase pressure drop for cryogenic fluids. **07**

OR

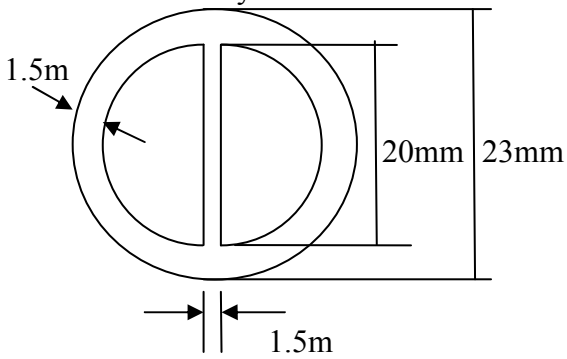
Q.4 **(a)** State types of cryogenic heat exchangers. Explain with neat sketch 'Collin's Exchanger'. **07**

(b) Derive the finite difference equation for two-dimensional steady state heat conduction in rectangular plate with internal heat generation for, **07**

1. Internal node
2. Surface node subjected to radiation heat transfer with surrounding

Q.5 **(a)** Explain with neat sketch Gifford single volume cryorefrigerator. **07**

(b) Determine the fin effectiveness and surface effectiveness for the configuration shown in Figure if nitrogen gas at 95 K and 140 kPa is flowing inside the tube. The tube wall has a temperature of 105 K and the mass flow rate of nitrogen gas is 40 g/s. The tube has an inside diameter of 20 mm, the fin thickness is 1.5 mm and fin thermal conductivity is 225 W/m-K. **07**



OR

Q.5 **(a)** Explain with suitable example the effect of regenerator effectiveness on system performance **07**

(b) Determine the frictional pressure drop for adiabatic flow of two phase hydrogen in a 162.7 mm diameter pipe for a total mass flow rate of 4 kg/s and a fluid quality of 0.1. The liquid hydrogen is flowing at an average pressure of 354.6 kPa. The length of line is 160 m. **07**

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