Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

M.E Sem-I Examination January 2010

Subject code: 712105

Subject Name: Cryogenic Heat Exchangers

Date: 29 / 01 / 2010 **Time: 12.00 – 2.30 pm**

Total Marks: 60

Instructions:

1. **Attempt all questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**

Q.1 **(a)** Explain the term 'conduction shape factor' & write the conduction shape factor for the following cases: **06**
(i) Isothermal cylinder of radius 'r' placed in semi infinite medium.
(ii) Hollow cylinder of length 'L'.
(iii) Corner section of three homogeneous walls of thickness 'Δx'.

(b) With neat sketch explain the procedure for graphical analysis of two-dimensional heat conduction in a plane wall. **06**

Q.2 **(a)** Explain following terms: **06**
(i) Nucleate boiling
(ii) Film boiling
(iii) Interface evaporation.

(b) State and explain Lockhout Mantinelli correlation of two phase pressure drop for cryogenic fluids. **06**

OR

(b) In what important aspects do the heat exchangers used in cryogenic services differs from those used in general services? **06**

Q.3 **(a)** Compare 'NTU-effectiveness' and 'LMTD' heat exchanger design methods. **06**

(b) An oil cooler for a lubrication system has to cool 1000kg/hr of oil (C_p = 2.09 kJ/kg ^{0}C) from 80 ^{0}C to 40 ^{0}C by using a cooling water flow of 1000 kg/hr at 30 ^{0}C. Give your choice for a parallel flow or counter-flow heat exchanger, with reasons. Calculate the surface area of the heat exchanger, if the overall heat transfer coefficient is 24 W/m^2-^{0}C. **06**

OR

Q.3 **(a)** State types of cryogenic heat exchangers. Explain with neat sketch 'Giauque-Hampson Exchanger'. **06**

(b) Explain regenerative heat exchanger. State its importance in Stirling cycle cryocooler. **06**

Q.4 **(a)** Explain simple Linde-Hampson liquefaction system. **06**

(b) Determine the heat transfer coefficient for nitrogen gas flowing inside a straight circular tube having an inside diameter of 20 mm. The nitrogen gas is at a bulk temperature of 95 K, and the tube wall has a temperature of 105 K. The mass flow rate of the nitrogen is 40 gm/sec, and the gas pressure is 140 kPa. Further determine the pressure drop per unit length of tube. **06**

OR

Q.4 **(a)** Discuss effect of heat-exchanger effectiveness on performance of a liquefaction system with suitable illustration. **06**

(b) Explain importance of compact heat exchangers over traditional design. Discuss basic aspects of compactness for a heat exchanger. **06**

Q.5 **(a)** A regenerator is constructed of 1.882 kg of metal spheres (C_s = 0.840 kJ/kg-K and k_s = 155 W/m-K). The heating and cooling periods are equal at 2 seconds. the fluid flowing through the regenerator is helium gas (C_p = 5.200 kJ/kg-K) for both steams. The mass flow rate of the hot steam is 40 gm/sec, and the mass flow rate of the cold stream is 36 gm/sec. the convective heat transfer coefficients are $h_h = h_c$ = 8320 W/m^2-K, and the heat transfer areas are $A_h = A_c$ =0.950 m^2. Determine the regenerator effectiveness. **06**

Reference data: Effectiveness of a counterflow regenerator as a function of N_{tu} and C_m for $C_R = C_{min}/C_{max}$ =1.0

Matrix capacity rate ratio, C_m				
N_{tu}	1.0	1.5	2.0	3.0
0	0	0	0	0
1.0	0.467	0.485	0.491	0.496
5.0	0.738	0.791	0.809	0.822
10.0	0.811	0.869	0.886	0.898
20.0	0.865	0.922	0.935	0.943
30.0	0.889	0.943	0.947	0.961
50.0	0.914	0.962	0.970	0.975

(b) What are TEMA standards? Discuss any three useful TEMA configurations for heat exchangers. **06**

OR

Q.5 **(a)** Discuss selection criteria for a heat exchanger as per standards. **06**

(b) Discuss construction, working and design aspects of a Plate-fin type heat exchanger. **06**

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