Seat No.: _____ *Enrolment No._____*

GUJARAT TECHNOLOGICAL UNIVERSITY

M. E. - SEMESTER – I • EXAMINATION – WINTER • 2013

Subject code: 711006N **Date: 06-01-2014**

Subject Name: Cryogenic Heat Exchangers

Time: 10.30 am – 01.00 pm **Total Marks: 70**

Instructions:

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

Q.1 **(a)** Explain how the cryogenic heat Exchangers are different than conventional heat Exchangers? Classify it and draw the neat line sketches of any four cryogenic heat exchangers. **07**

(b) Explain the importance of NTU-effectiveness method in heat transfer. Derive the equations for NTU and Effectiveness for parallel flow heat exchangers. **07**

Q.2 **(a)** Compare recuperative and regenerative heat exchangers. **07**

(b) Explain different regimes of two – phase flow with sketches. **07**

OR

(b) Explain forced convection boiling inside a vertical tube. **07**

Q.3 **(a)** A tube bank counter flow heat exchanger is used to warm helium gas (c_p=5.2 kJ/kg-K) from an inlet temperature of 20 K to an outlet temperature of 206 K. The heating fluid is nitrogen gas (c_p=1.050 kJ/kg-K), which enters at 305 K at mass flow rate of 1.86 kg/s. The helium gas flows within the tubes at a mass flow rate of 0.30 kg/s, and the nitrogen gas flows over the tubes. The overall heat transfer coefficient for the heat exchanger is 160 W/m^2-K. Determine the required heat transfer surface area for the exchanger. **07**

(b) Write short note on Thermal contact resistance. **07**

OR

Q.3 **(a)** In a plate fin heat exchanger, the frontal area is 5.00 m2 and the ratio of free flow area to frontal area is 0.40. the equivalent diameter of the flow passages is 3.6 mm. The gas flowing through the heat exchanger is methane (viscosity, 0.0150 mPa-s), which flows at a mass flow rate of 25.0 kg/s. The density of the methane at the heat exchanger inlet is 2.00 kg/m3, the density at outlet is 1.00 kg/m3 and the density at the bulk of average conditions is 1.333 kg/m3. The length of the core in the direction of flow is 238.8 mm. the contraction coefficient is Kc= .50, and the expansion co-efficient Ke= 0.30. The core friction factor correlation (based on the equivalent diameter) is given by $F=1.115\boldsymbol{Re}^{-0.25}$. Determine the total pressure drop through the heat exchanger for the methane stream. **07**

(b) Explain: What is cool down? Why it is needed? and explain cool down of cryogenic vessel **07**

Q.4 **(a)** List out and discuss the applications of cryogenic heat transfer. **07**

Continue…….

(b) A pipe of 10 cm OD passes through the centre of a concrete slab of cross-section 50 cm x 50 cm. The outer surface of the pipe is maintained at 135^{o}C while the outer surface of the concrete slab is at 35^{o}C. Using the flux plot, estimate the heat loss per metre length of the pipe. Take conductivity of concrete: 1.37 J/kg-K. **07**

OR

Q.4 **(a)** Define shape factor and thermal conductivity integral. Give shape factors for following shape (i) Hollow cylinder (ii) hollow sphere (iii) Isothermal cylinder buried in a semi-infinite medium (iv) plane wall (v) Isothermal cylinder placed vertically in a semi-infinite medium **07**

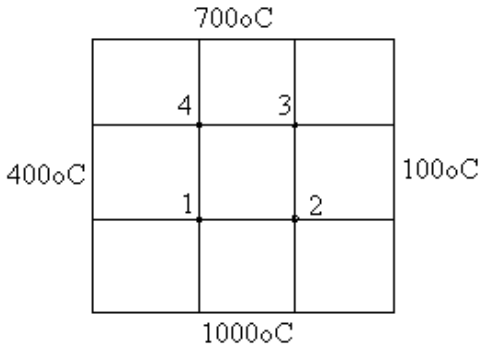
(b) A heat exchanger in a Linde Hampson system operates with the following parameters: **07**

- Type of heat Exchanger – Counter flow
- Warm fluid: air at 20.265 Mpa , mass flow rate = 1.25 kg/s
- Th1 = 300 K; Cph = 1.588 kJ/kg-K
- Cold fluid: air at 101.3 kPa; mass flow rate = 1.149 kg/s
- Tc1 = 81 K; U = 120 W/m^{2}K; Area A = 70 m^2

Determine the heat transfer rate for this exchanger and the exit tempertaure of the two fluids.

Q.5 **(a)** Explain the design methodology of single shell, double pass tube heat exchanger. **05**

(b) Estimate the temperatures at points 1, 2, 3 and 4 shown in figure using the relaxation technique. **09**



OR

Q.5 **(a)** What is compact heat exchanger? Explain the design methodology of plate-fin heat exchangers. **07**

(b) A valved-type regenerator has a matrix of 2688 kg of steel shot (c_s= 0.48 kJ/kg-K). The mass flow rate of the hot stream and cold stream is 1.80 kg/s. The total period for the regenerator is 9.00 minutes. The convective heat transfer co-efficient for the hot fluid is 416 W/m^2-K, and the convective heat transfer for the cold fluid is 388 W/m^2-K. The surface area for both the hot and cold streams is same & equal to 180 m^2. Determine the effectiveness for the regenerator. The regenerator and both the streams are air (c_p = 1.006 kJ/kg-K). **07**

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