Birla Institute of Technology and Science, Pilani
ME G536: Thermal Equipment Design – Compre-Exam.
Part A: Closed book Exam, Max Marks :20
Date: 16/05/2023, Time:1515 – 1545 Hrs

Note: Write short answers in the space given

1 Mark

Q1) What is deference between convective boiling and nucleate boiling?

2 Marks

Q2) Draw boiling curve as super heat vs heat flux.

2 Marks

Q3). Write the equation of LMTD for counter flow heat exchanger and with a sketch, temperatures vs flow length of heat exchanger.

2 Marks

Q4) Define hydraulic diameter for compact plate fin heat exchangers and indicate its ranges for CHE's.

1 Mark

Q5) What is difference between super-heat and sub-cooling in two-phase heat exchangers?

2 Marks

Q6) Define Knudsen and Peclet numbers for gas flows in micro channel heat exchangers and give equations for the same.

2 Marks

Q7) Explain the Capillary limitation and the Sonic limitation in the Heat pipes?

2 Marks

Q8) Difference between Length of transfer unit and Length of Dryer and show the relation between them?

2 Marks

Q9) What are the Range and the Approach in Cooling Towers?

2 Marks

Q10) Define Cycles of Concentration (CoC) and how it is related to Cooling Tower Blow Down?

2 Marks

Q11) Explain the difference between Evaporation Loss and Drift Loss in Cooling Towers.

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ME G536-Thermal Equipment Design
Compre. Exam (Part B - Open Book)

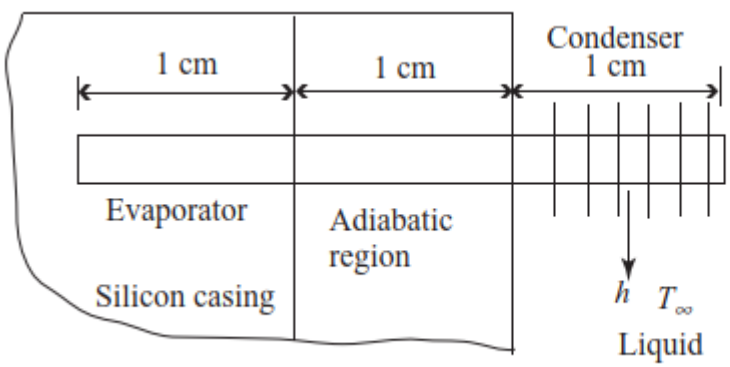
Date: 16/05/2023, Time:1545 – 1800 hrs; Max Marks :60

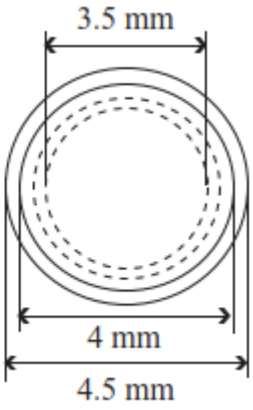
1. The sizing of an engine bleed Pre-cooler is carried out for the air-conditioning system of an aircraft with the hot bleed air 30 kg/min at 5 bar g, which is needs to be cooled from 500^{o}C to 350^{o}C, and the Ram air 120 kg/min at 1.2 bar g is available at a temperature of 70^{o}C, and found the required space for a single pass cross flow plate-fin compact heat exchanger is 155 mmx150 mm x138 mm(height), using Offset fins (20 FPI, 5 mm fin height, 3.175 mm offset length and 0.1 mm fin thickness) on hot side and wavy fins (11.5 FPI, 9.5 mm wave length, 2 mm amplitude, 0.15 mm fin thickness and 10.5 mm fin height) on Ram air side.

   Carryout the mechanical design and find the total weight of the proposed CHE with stainless steel throughout. Assume the separating plates thickness is 0.2 mm each and top & bottom plates thickness is 0.35 mm each.

   20 Marks

2. A simple horizontal copper-water heat pipe is to be constructed from a 3-cm-long tube to cool an enclosed silicon casing, as shown in Figure below. The inner and outer diameters of the heat pipe are 4 mm and 4.5 mm, respectively. The diameter of the vapor space is 3.5 mm, also shown. The evaporator and condenser lengths of the heat pipe are 1 cm each and the wicking structure consists of two layers of #500-mesh copper screen with the wire diameter of 0.00085 in. The evaporator of the heat pipe is embedded in a silicon casing, and the contact resistance between the heat pipe and its casing is 1.5×10^{-5} $m^2{}^{\circ}C/W$. The condenser is immerged in a stream of liquid and the convection heat transfer coefficient at the condenser is 700 $W/m^2{}^{\circ}C$. If the liquid is at 20°C, and the heat pipe is operating at a heat transfer rate of 1.5 W, what is the temperature of the silicon casing?





15 Marks

3. A 5% aqueous solution of a high molecular weight solute has to be concentrated to 40% in a forward-feed double effect evaporator at the rate of 7000 $kg.h^{-1}$. The feed temperature is 40°C. Saturated steam at 3.5 $kg.cm^{-2}$ is available for heating. A vacuum of 550 mm Hg is maintained in the second effect. Calculate the area requirements and proceed with max area by selecting 1¼ inch nominal diameter, 80 schedule, brass tubes of 12ft in length (Note: No iteration is required). The overall heat transfer coefficients are 550 and 370 $kcal.h^{-1}m^{-2}\ °C^{-1}$ in the first and the last effect respectively. The specific heat of the concentrated liquor is 0.87 $kcal.kg^{-1}°C^{-1}$.

15 Marks

4. A natural draught cooling tower used in a large cold storage plant receives water from the condenser outlet at a flow rate of 28000 kg/sec and 38^0C temperature. The ratio of flow rate of water to air is 1.2:1 in the cooling tower. Inlet condition of the air entering the cooling tower is dry-bulb temperature (DBT) of 20^0C and wet-bulb temperature (WBT) of 10^0C. Air leaves the cooling tower at DBT of 35^0C with relative humidity of 85%. For this cooling tower,

   a) draw the inlet and exit conditions of air in psychrometric chart and name the process;
   b) determine the rate of evaporation of water in kg/sec;
   c) determine the heat carried away by the air;
   d) determine the maximum possible temperature drop of water realizable.

   (Psychometric chart enclosed)

10 Marks