Sub.: Heat Transfer operations - II 22/5/15

CHEM/VI/CBGS/HTO-II

(1)

(30)

QP Code : 5151

(REVISED COURSE)
(3 Hours)

[Total Marks: 80

N.B. :

1) **Question – 1 is compulsory.** Answer any **three** questions from remaining.
2) Use of **"Heat Exchanger databook"**is permitted.
3) Assume data if necessary and **specify the assumptions** clearly.
4) Draw neat sketches wherever required.
5) Answer to the sub-questions of an individual question should be grouped and written together i.e. one below the other.

1. (a) If calculated bridgewall temperature is less than assumed one, how does it affect the furnace design? **[05]**

   (b) How do non-condensables affects condenser operation? **[05]**

   (c) List gasket materials used in plate heat exchanger with their respective applications. **[05]**

   (d) Explain tube plugging in the context of overdesign of shell and tube heat exchanger. **[05]**

2. A 19,400 LPH condensate water need to be cooled from 65°C to 45°C before being discharge in open trench, using cooling water available at 25°C. Temperature of cooling water at inlet of cooling tower should not exceed 42°C. It is decided to use Plate Heat Exchanger for this duty with stainless steel (k = 15 $W/m \cdot K$) plates of 0.75 mm thick. Maximum operating pressure and allowable pressure for both fluids is 3 barg and 0.7 bar respectively and maximum permissible velocity is 3 m/s. **[20]**

   Show one iteration of design calculation including thermal and hydrodynamic and if design is not satisfactory in first iteration then comment on the calculations?

   Data:

Property	Cooling water	Condensate
Specific heat, $kJ/kg \cdot K$	4.179	4.183
Viscosity, cP	0.705	0.504
Thermal conductivity, $W/m \cdot K$	0.6248	0.6493
Density, kg/m^3	993.685	985.69

3. The return line from a thermosyphon reboiler consists of 10-in. schedule 40 pipe with an ID of 254.5 mm. The total mass flow rate in the line is 136,078 kg/h, of which 27,216 kg/h (20%) is vapour and 108,862 kg/h is liquid. Physical properties of the vapour and liquid fractions are given in the following table:

Property	Liquid	Vapour
μ, cP	0.177	0.00885
ρ, kg/m^3	623.76	7.668
σ, $dyne/cm$	11.4	

Calculate the friction loss per unit length in the line using:

i) The Lockhart-Martinelli correlation . [08]

ii) The Friedel correlation. [08]

Also comment on result. [04]

4. (a) 22680 kg/h of saturated acetone vapour will be condensed at 80°C and 2.14 bar(a) using a tube bundle containing 316 tubes arranged for a single pass. The tubes are 25.4 mm OD, 16 BWG with a length of 7.62 m. The molecular weight of acetone is 58.08 and the liquid specific gravity is 0.79. For the purpose of this problem, assume constant physical properties and neglect the effects of condensate subcooling and interfacial shear. Calculate the condensing-side heat-transfer coefficient for the tube bundle is vertical and condensation occurs inside the tubes. [16]

Data:

Density of condensate, kg/m^3	791.0
Viscosity of condensate, cP	0.3311
Thermal conductivity of condensate, $W/m \cdot K$	0.1512
Specific heat of condensate, $kJ/kg \cdot K$	2.1562

(b) Explain working of kettle type reboiler with neat sketch. [04]

5. Condensate from methanol condenser is sub-cooled in shell and tube heat exchanger from 95°C to 40°C. Flow rate of methanol is 100,000 kg/h. Properties of methanol at average temperature are, [20]

Specific heat, $kJ/kg \cdot K$	2.84	Thermal conductivity, $W/m \cdot K$	0.19
Viscosity, cP	0.34	Density, kg/m^3	750

Using Bell-Delware method, calculate the shell side heat transfer coefficient for following data.

Summary of proposed design					
Number of tubes	918		Pitch 1.25Δ	25	mm
Shell ID	894	mm	Tube length	4830	mm
Bundle diameter	826	mm	Baffle pitch	356	mm
Tube OD	20	mm			

6. (a) What are the factors to be considered for allocation of fluid in shell or tube? [12]

(b) Draw schematic diagram of any one type box furnace showing different sections. Also explain its operation. [08]

****