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UNIVERSITY OF PETROLEUM AND ENERGY STUDIES

End Semester Examination, December 2017

Program: B.Tech. APE Gas	**Semester – VII**
Subject (Course): Petroleum Refining Systems Design	**Max. Marks : 100**
Course Code : CHEG 431	**Duration : 3 Hrs**
No. of page/s: 05	

Note: Assume suitable data, if necessary.

Section A

Answer all questions. Each carries 15 marks. [15X4=60 Marks]

Q.1 Describe with diagrams, various tube arrangements for shell and tube heat exchangers (STHEs). Also describe types of baffles used in STHEs. Draw diagrams. **[15]**

Q.2 Light crude oil coming from storage at 40^0C exchanges heat with kerosene leaving the base of a kerosene side-stripping column at 200^0C in a shell and tube heat exchanger (1-4). A pressure drop of 0.8 bar is permissible on both streams. Tube side fluid is light crude oil while shell side fluid is kerosene. Calculate pressure drop on shell side as well as tube side. Neglect viscosity correction on either side. Use Eqn 1 and 2 for calculation of pressure drop on tube and shell side respectively. Refer to Figs. 1 and 2. Comment on your answers. **[15]**

Data for Q.2:

Flow rate of light crude oil = 70000 kg/h
Flow rate of kerosene = 20000 kg/h

Number of tubes = 240
Number of tube side passes = 04
Tube inside diameter = 14.83 mm
Length of one tube = 5 m
Tube arrangement = Triangular pitch

Shell inside diameter (D_s) = 0.8 m
Shell equivalent diameter (d_e)= 13.52 mm
Baffle type = segmental (Baffle Cut % = 25)
Baffle spacing (l_B) = 0.2 D_s

Tube side velocity = 2.3 m/s
Shell side velocity = 0.75 m/s

Data for Q.2:

Density of light crude oil = 820 kg/m^3
Density of kerosene = 730 kg/m^3

Viscosity of light crude oil = 3.2 X 10^{-3} Ns/m^2
Viscosity of kerosene = 0.43 X 10^{-3} Ns/m^2

$$\Delta P_t = N_p \left[8 j_f \left(\frac{L}{d_i} \right) \left(\frac{\mu}{\mu_w} \right)^{-m} + 2.5 \right] \frac{\rho u_t^2}{2}$$

where ΔP_t = tube-side pressure drop, N/m^2 (Pa),
N_p = number of tube-side passes,
u_t = tube-side velocity, m/s,
L = length of one tube.

-----Eqn1

$$\Delta P_s = 8 j_f \left(\frac{D_s}{d_e} \right) \left(\frac{L}{l_B} \right) \frac{\rho u_s^2}{2} \left(\frac{\mu}{\mu_w} \right)^{-0.14}$$

where L = tube length,
l_B = baffle spacing.

-----Eqn2

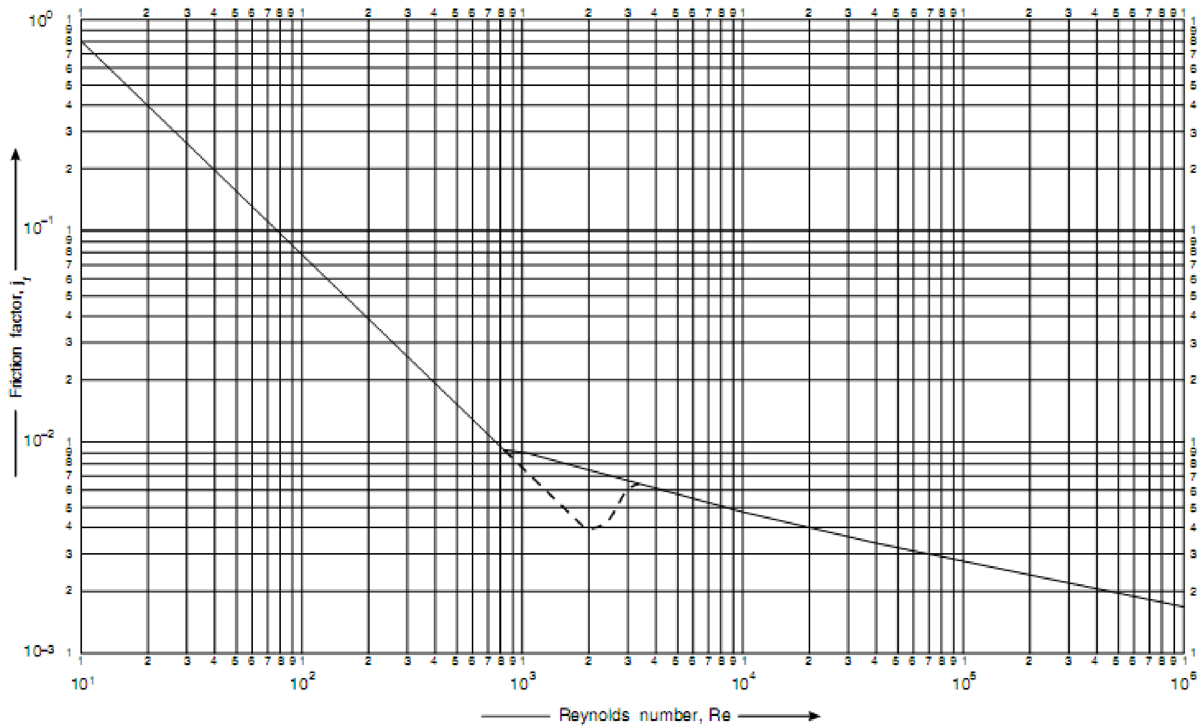

Figure 1 Tube-side friction factors

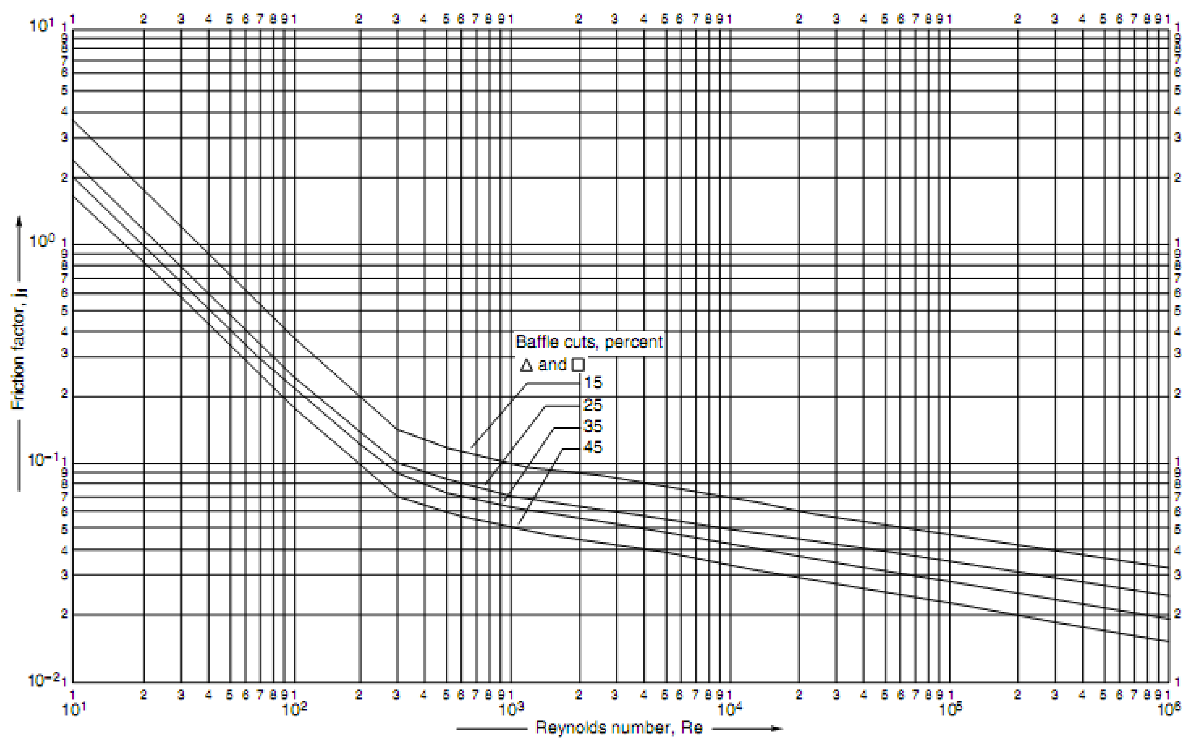

Figure 2 Shell-side friction factors, segmental baffles

Q.3 Describe with flow diagram, atmospheric topping unit of the refinery. **[15]**

Q.4 Explain with flow diagram, CCR Platforming Process. **[15]**

Section B

Answer any two questions. Each carries 20 marks. **[20X2= 40 Marks]**

Q.5 A distillation column is used to separate 4750 mol/h of feed composed of 37% n-butane, 32% iso-pentane, 21%n-pentane and 10%n-hexane. The column operates at an average pressure of 2 atm a and will produce a distillate product containing 95% n-butane and 5% iso-pentane. The bottom product is allowed to contain no more than 570 mol/h of n-butane. Feed is 25% (by mole) vapor. Assume ideal vapor-liquid equilibrium. All compositions are mole%. Using FUG method, determine number of equilibrium stages for desired separation for different values of reflux ratio (1.7, 2, 2.5, 3, 3.5, 4). Assume n-butane as light key (LK) while iso-pentane as heavy key (HK) component. Minimum reflux ratio (R_m) determined by Underwood's method is 1.4509 Refer to Eqn 3 and 4. **[20]**

Data for Q.5

Column top temperature = 22^0C
Column bottom temperature = 47^0C
Vapor pressure of LK component at 22^0C = 2.17 atm
Vapor pressure of HK component at 22^0C = 0.8 atm
Vapor pressure of LK component at 47^0C = 4.478 atm
Vapor pressure of HK component at 47^0C = 1.842 atm

Fenskey's equation

$$N_m = \frac{\log\left[\left(\frac{x_{LK}}{x_{HK}}\right)_d \left(\frac{x_{HK}}{x_{LK}}\right)_b\right]}{\log \propto_{LK}}$$

where, $\propto_{LK}$ = Average relative volatility of light key with respect to heavy key
$(x_{LK}, x_{HK})_d$ = Mole fraction of light key and heavy key in distillate
$(x_{LK}, x_{HK})_b$ = Mole fraction of light key and heavy key in residue

------Eqn 3

Gilliland's correlation

$$f(N) = \frac{N - N_m}{N+1} = 1 - \exp\left[\left(\frac{1+54.4\psi}{11+117.2\psi}\right)\left(\frac{\psi - 1}{\psi^{0.5}}\right)\right]$$

where, $$\psi = \frac{R - R_m}{R+1}$$

-----Eqn 4

Q.6 Calculate minimum-utility requirements and pinch point for a HEN problem by using the problem table algorithm of Linnhoff and Flower. The stream data for the same problem is as follows. Take the value of $\Delta T_{min} = 10^0C$. **[20]**

Stream Data

Stream	Type	*TS* (°C)	*TT* (°C)	*CP* (kW/°C)	Duty (kW)
1	Hot	150	60	2.0	180
2	Hot	90	60	8.0	240
3	Cold	20	125	2.5	262.5
4	Cold	25	100	3.0	225

where $CP \equiv \dot{m}C_P$ = heat capacity flow rate

TS = supply temperature

TT = target temperature

Q.7 Describe with sketch, Reactor-Regenerator system of FCCU. Discuss operating considerations related to Riser. Also discuss FCC catalyst additives. **[20]**