

GUJARAT TECHNOLOGICAL UNIVERSITY**M. E. - SEMESTER – II • EXAMINATION – SUMMER • 2013****Subject code: 1723003****Date: 03-06-2013****Subject Name: Advance Equipment Design****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 marks.

- Q.1** Design a cyclone (with a neat sketch showing all dimensions) to recover solids from a process gas stream. The anticipated particle size distribution in the inlet gas is given below. The density of the particles is 2500 kg/m^3 , and the gas is essentially nitrogen at 150°C . The stream volumetric flow-rate is $4000 \text{ m}^3/\text{hr}$, and the operation is at atmospheric pressure. An 80% recovery of the solids is required. Take velocity = 15 m/sec , $f_c = 0.005$ and $\eta = 0.9$. The performance curve at standard condition is given in Fig. (1). **14**

Particle size (μm)	50	40	30	20	10	5	2
Percentage by weight less than	90	75	65	55	30	10	4

- Q.2 (a)** Calculate the rate of radiant heat flow from the flue gas to the wall of a cylindrical flue duct having a diameter of 60 cm. The gas contains 12% CO_2 and 8% H_2O and the total pressure of the gas is 1 atm. The inlet and outlet temperature of the flue gas is 900°C and 700°C . The outer surface temperature of the tubes is 500°C . The emissivity of the tube surface = 0.8. **07**
- (b)** Derive the relation between thickness of cake and the volume of filtrate for a filtration unit. **07**

OR

- (b)** A batch centrifugal filter having a bowl diameter of 750 mm and a bowl height of 450 mm is used to filter a suspension having the following properties: **07**

Data:

Liquid: Water

Temperature: 25°C

Concentration of solid in feed: 60 g/ltr

Porosity of cake: 0.835

Density of dry solid in cake: 2000 kg/m^3

Final thickness of cake: 150 mm

Speed of centrifuge: 2000 rev/min

Specific cake resistance: $1.31 \times 10^{10} \text{ m/kg}$ Filter medium resistance: $8.53 \times 10^{10} \text{ m}^{-1}$

The final cake is washed with water under such conditions that the radius of the inner surface of the liquid is 200 mm. Assuming that the rate of flow of wash water equals the final rate of flow of filtrate, what is the rate of washing in m^3/hr ?

- Q.3 (a)** A solution containing 23% by mass of sodium phosphate is cooled from 313 K to 298 K in a Swenson-Walker Crystallizer to form crystals of $\text{Na}_3\text{PO}_4 \cdot 12\text{H}_2\text{O}$. The solubility of Na_3PO_4 at 298 K is 15.5 kg/100 kg water, and the required flow of crystals is 0.063 kg/sec. The mean heat capacity of the solution is 3.2 KJ/kgK and the heat of crystallization is 146.5 KJ/kg. If cooling water enters and leaves at 288 and 293 K respectively, and the overall coefficient of heat transfer is $0.14 \text{ KW/m}^2\text{K}$, what length of crystallizer is required? Assume that evaporation is negligible. **07**
- (b)** A plate and frame press, filtering slurry, gave a total of 8 m^3 of filtrate in 1800 sec and 11 m^3 in 3600 sec, when the filtration was stopped. Estimate the washing time in seconds if 3 m^3 of wash water are used. The resistance of the cloth can be neglected and a constant pressure is used throughout. **07**

OR

- Q.3** Filtration is carried out in a plate and frame filter press, with 20 frames 0.3 m and 50 mm thick, and the rate of filtration is maintained constant for the first 300 sec. During this period, the pressure is raised to 350 KN/m^2 , and one-quarter of the total filtrate per cycle is obtained. At the end of the constant rate period, filtration is continued at a constant pressure of 350 KN/m^2 for a further 1800 sec, after which the frames are full. The total volume of filtrate per cycle is 0.7 m^3 and dismantling and refitting of the press takes 500 sec. **14**
- It is decided to use a rotary drum filter, 1.5 m long and 2.2 m in diameter, in place of the filter press. Assuming that the resistance of the cloth is the same in the two plants and that the filter cake is incompressible, calculate the speed of rotation of the drum which will result in the same overall rate of filtration as was obtained with the filter press. The filtration in the rotary filter is carried out at a constant pressure difference of 70 KN/m^2 and the filter operates with 25% of the drum submerged in the slurry at any instant.

- Q.4** Flaked soyabeans are to be leached with hexane to remove the soyabean oil. A 14
0.3m thick layer of the flakes (0.25 mm flake thickness) will be fed onto a slowly moving perforated endless belt which passes under a series of continuously operating sprays. As the solid passes under each spray, it is showered with liquid which percolates through the bed, collects in a trough below the belt, and is recycled by a pump to a spray. The spacing of the sprays is such that the solid is permitted to drain 6 min before it reaches the next spray. The solvent also passes from trough to trough in a direction counter-current to that of the moving belt, so that a truly continuous countercurrent stagewise operation is maintained, each spraying and draining constituting one stage. Experiments show that the flakes retain solution after 6 min drain time to an extent depending upon the oil content of the solution, as follows:

Wt% oil in solution	0	20	30
Ks solution retained/kg insoluble solid	0.58	0.66	0.70

The retained solution contains the only oil in the drained flakes.

The soyabean flakes enter containing 20% oil and are to be leached to 0.5% oil (on a solvent-free basis). The net forward flow of solvent is to be 1.0 kg hexane introduced as fresh solvent per kilogram flakes, and the fresh solvent is free of oil. The solvent draining from the flakes is generally free of solid except in the first stage: the rich miscella contains 10% of the insoluble liquid in the feed as a suspended solid, which falls through the perforations of the belt during loading. How man stages are required?

OR

- Q.4** A tray dryer with 12 trays is available. Area of one tray is 1 m/m which can 14
accommodate 144 molds of wet cake of size 5 cm diameter and 5 cm height. One phase of the mold will be resting on the plate. For the given drying rate data to dry the material of 125 kg (bone dry), how much time will be required?

Data:

Initial moisture content, $X_1 = 0.2$ kg/kg of dry solid

Final moisture content, $X_2 = 0.02$ kg/kg of dry solid

Density of wet cake = 1740 kg/m^3

Drying rate data:

Moisture content, X, kg/kg dry solid	0.3	0.2	0.14	0.096	0.056	0.046	0.026	0.016
Rate, N, kg/hr-m ²	1.71	1.71	1.71	1.46	1.29	0.88	0.54	0.376

- Q.5 (a)** In order to extract acetic acid from dilute aqueous solution with isopropyl ether, the two immiscible phases are passed counter-currently through a packed column 3 m in length and 75 mm in diameter. **07**

It is found that, if $0.5 \text{ kg/m}^2\text{s}$ of the pure ether is used to extract $0.25 \text{ kg/m}^2\text{s}$ of 4.0% acid by mass, then the ether phase leaves the column with a concentration of 1.0% acid by mass. Calculate:

- (a) the number of overall transfer units based on the raffinate phase; and
- (b) the overall extraction coefficient based on the raffinate phase.

The equilibrium relationship is given by: $(\text{kg acid/kg isopropyl ether}) = 0.3 (\text{kg acid/kg water})$.

- (b)** A granular material containing 40% moisture is fed to a counter current rotary dryer at a temperature of 295 K and is withdrawn at 305 K containing 5% moisture. The air supplied, which contains 0.006 kg water vapor/kg dry air, enters at 385 K and leaves at 310 K. The dryer handles 0.125 kg/s wet stock. **07**

Assuming that radiation losses amount to 20 KJ/kg dry air used, determine the mass flow of dry air supplied to the dryer and the humidity of the exit air.

Latent heat of water vapor at 295 K = 2449 KJ/kg, specific heat of dried material = 0.88 KJ/kg K, specific heat of dry air = 1.00 KJ/kg K, specific heat of water vapor = 2.01 KJ/kg K.

OR

- Q.5 (a)** List out various types of furnaces used in petroleum industry. Explain any one in detail with the help of neat sketch. **07**

- (b)** Explain Swenson Reaction type DTB crystallizer with the help of neat sketch. **07**

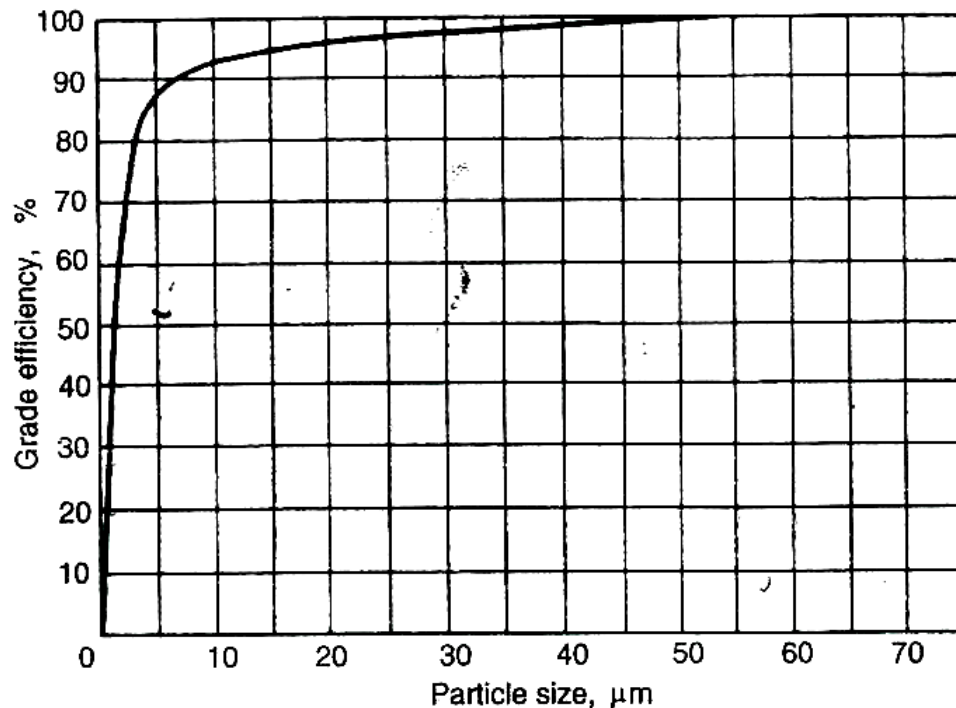


Fig. 1 Performance curve, standard conditions

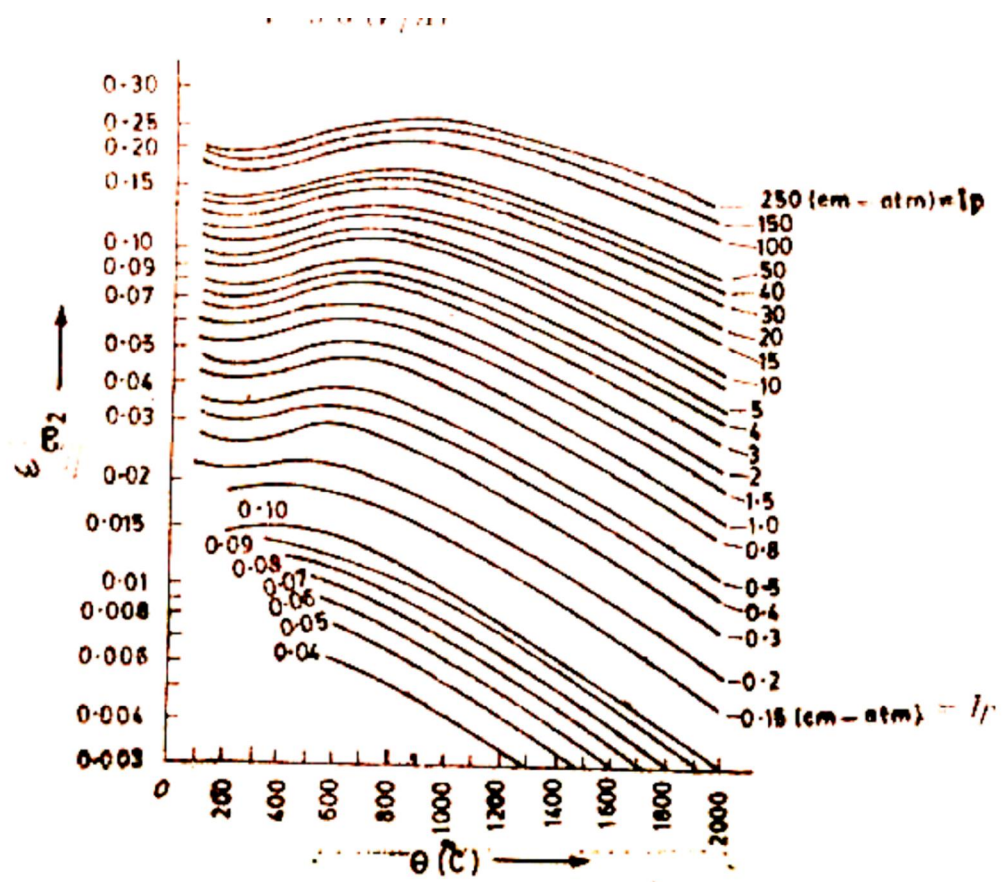


Fig. 2 Emissivity of Carbon-dioxide

Fig. 3 Emissivity of Water Vapour

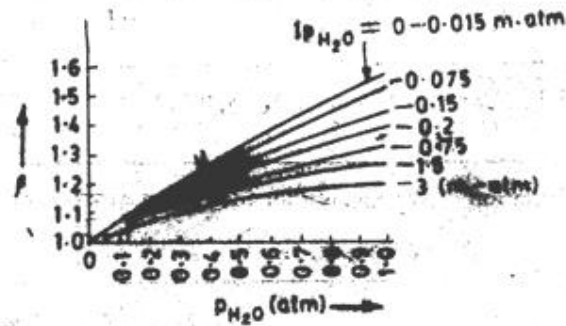
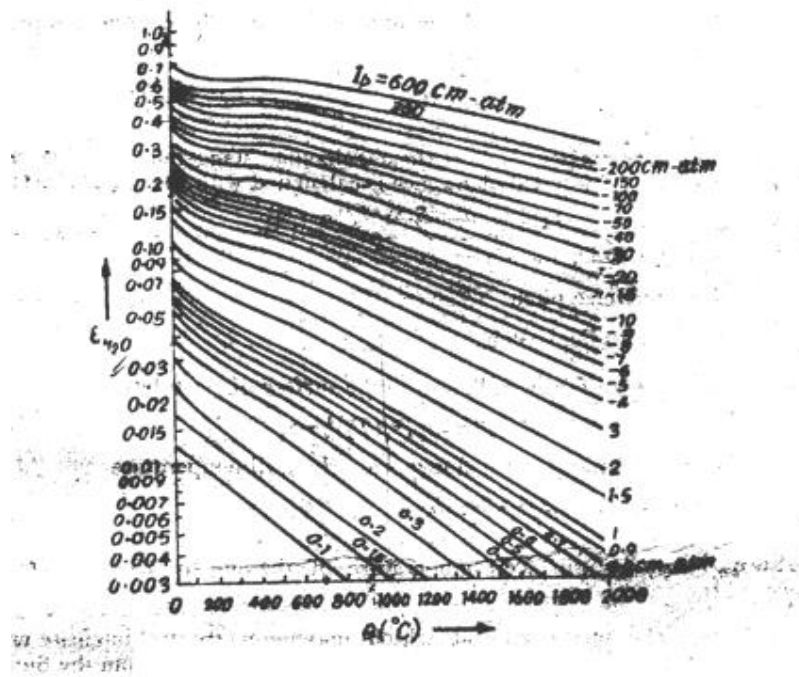


Fig.4 $C\beta$ vs p_{H_2O}
