THAPAR INSTITUTE OF ENGINEERING AND TECHNOLOGY, PATIALA

CH – 003

MECHANICAL OPERATIONS

End – Semester Examination

(December 06, 2006)

Time: 3 hour | Max. Marks: 36

Note: Attempt any FOUR questions.

I. (A) Define the term "Sphericity." Find the sphericity of a cylinder 1 cm diameter and length 3 cm. (3)

(B) The power required to crush 100 tons/hr of material is 179.8 kw, 80% of the feed passes through a 51 mm screen and 80% of the product passes through a 3.2 mm screen. What is the work index of the material? What will be the power required for the same feed at 100 ton/hr to be crushed to a product such that 80% is to pass through a 1.6 mm screen? (3)

(C) Solids may be broken in many different ways, but only four of them are commonly used in size-reduction machines. Name these four ways. List principal types of size-reduction machines. (3)

II. (A) Calculate the surface-volume mean diameter for the following particulate material. Show the detailed calculations. (3)

Size range, μm	Mass of particles in the range, gm
-704 + 352	25.0
-352 + 176	37.5
- 176 + 88	62.5
- 88 + 44	75.0
Pan	50.0

(B) Prove the following relationship for the effectiveness(E) of a screen:

$$E = \frac{(x_F - x_B)(x_D - x_F)x_D(1 - x_B)}{(x_D - x_B)^2(1 - x_F)x_F}$$

where

x_F = mass fraction of material A in feed(F)

x_D = mass fraction material A in over flow (D) (3)

x_B = mass fraction of material A in underflow (B)

(C) Define the terms (i) "Screening" and (ii) "Efficiency of screening". Sketch a cumulative analysis plot in terms of: (3)

[Cumulative mass fraction smaller than D_{pi}] versus [D_{pi})

where D_{pi} is average diameter in the increment.

III. (A) A solid particle of diameter D_p and density ρ_p on freely falling in a column of liquid (having density ρ and viscosity μ) attains a terminal velocity u_t given by relation:

$$u_t = \frac{gD_p^2(\rho_p - \rho)}{18\mu}$$ (5)

Prove this relation. What is the major assumption involved in it.

(B) A binary mixture of 100 µm size having densities of 2 gm/cm^3 and 4 gm/cm^3 is to be classified by elutriation technique using water. Estimate the range of velocities that do this job. Assume Stoke's law is valid. Given:

(i) viscosity of water = 0.001 kg/m-sec., and

(ii) density of water = 1000 kg/m^3 (4)

IV. (A) Describe with the help of a plot the effect of fluid velocity on pressure drop over fixed and fluidized bed. Explain the procedure for finding the minimum fluidizing point for a given packed bed. (4)

(B) A bed consists of uniform spherical particles of diameter 3 mm and density 4200 kg/m^3. What will be the minimum fluidizing velocity of a liquid having viscosity 3 mN.S/m^2 and density 1100 kg/m^3. Assume value of voidage at the minimum fluidization to be 0.4. Given the following relationship at minimum fluidization: $\left(2\frac{1}{2}\right)$

$$R_e = 25.7\,[(1+5.53\times10^{-5}\,Ga)^{1/2} - 1]$$

where R_e is Reynold number and Ga is Galileo number.

(C) A tube of 0.05m^2 crossectional area is packed with spherical particles upto a height of 0.25 m. The porosity of the bed is 0.35. It is desired to fluidize the particles with water (ρ =1000 kg/m^3, μ = 10^{-3} Pa.s). Calculate the minimum fluidization velocity of fluidization. Given:

(i) Diameter of the particles = 0.01 m

(ii) Density of solid particles = 2600 kg/m^3

(iii) Ergun's equation $\left(2\frac{1}{2}\right)$

$$\frac{\Delta P}{\rho} = \frac{1.75V_s^2L(1-\varepsilon)}{D_p\varepsilon^3} + \frac{150\mu V_s(1-\varepsilon)^2}{D_p^2\varepsilon^3}\cdot\frac{L}{\rho}$$

V. (A) A filtration is carried out for 10 minutes at a constant rate in a leaf filter and thereafter it is continued at constant pressure. This pressure is that attained at the end of the constant rate period. If one quarter of the total volume of filtrate is collected during the constant rate period, what is the total filtration time? Assume that the cake is in compressible and the filter medium resistance is negligible. Given the following equations:

$$\frac{d\theta}{dV} = \frac{2V}{C} + \frac{2V_f}{C}$$

$$C = C_1\frac{(\Delta P)}{\alpha}$$

$$\alpha = \alpha_o(\Delta p)^s$$

where

V_f = volume of filtrate held in the filter medium.

V = volume of filtrate

θ = time (5)

α = specific cake resistance

s = Compressibility coefficient for filter cake

α_o, C_1 = constants

(B) A plate and frame filter press with a filtration area of 2.2 m^2 is operated with a pressure drop of 413 kN/m^2 and with a down time of 21.6 ksec. In a test with a small leaf filter 0.05 m^2 in area operating with a pressure difference of 70 kN/m^2, 0.00025 m^3 of filtrate was obtained in 300 secs and a total of 0.00040 in 600 secs.

For filtration carried out entirely at constant pressure:

$$\frac{t}{V} = B_1 V + B_2$$

where $B_1 = \left[\frac{r\mu v}{2A^2(\Delta P)}\right]$

$$B_2 = \left[\frac{r\mu L}{A(\Delta P)}\right]$$

t = time for filtration

A = Crossectional area of filter

ΔP = applied pressure difference

V = filtrate volume

μ = viscosity of filtrate fluid

L = Cake thickness

V = volume of cake deposited by unit volume of filtrate (4)

r = Specific cake resistance.

Find the values of B_1 and B_2 for filtration through this plate and frame filter press.

VI. (A) Derive Carman Kozeny Equation for velocity of fluid flow through a packed bed. (4)

(B) Describe in brief Centrifugal Pump in terms of:

(i) different elements of centrifugal pump, and

(ii) mechanism of suction of liquid from the sump by centrifugal pump. (5)

See your answerbook on 14.12.2006 at 12.15 PM in Mechanical Operation Lab.