Exam Date & Time: 25-Jan-2023 (09:30 AM - 12:30 PM)

MANIPAL ACADEMY OF HIGHER EDUCATION

THIRD SEMESTER B.TECH END SEMESTER EXAMINATIONS, JAN 2023

PARTICLE TECHNOLOGY [CHE 2154]

Marks: 50 **Duration: 180 mins.**

A

Answer all the questions.

Instructions to Candidates: Answer ALL questions Missing data may be suitably assumed

1) Explain the various methods of screen analysis for the determination of average particle size and specific surface area of the materials with its suitable assumptions. Which method is more reliable to determine the above parameters? (3)

A)

B) Compare and contrast between the ideal and actual screen (any 4 points) with suitable technical criteria. List out the possible ways to increase the effectiveness of the screen. (3)

C) 3 tons/hr of dolomite is produced by crushing and screening through a 24-mesh screen from the screen analysis data shown below. Calculate the overall effectiveness of the screen and total feed of the crushed material.

Mesh No		4	8	14	28	48	100	150
Screen size opening, cm		0.4699	0.2362	0.1170	0.0589	0.0295	0.0147	0.0104
Weight fraction retained (%)	Feed	14.3	20	20	28.5	8.6	5.7	2.9
	Overflow	20	28	28	24	---	---	---
	Underflow	---	---	10.5	29.5	30	20	10

(4)

2) Derive an expression to determine the critical speed (N_c) of the ball mill.

(3)

A)

B) The Gypsum rock crushed materials are obtained using a pilot-scale Jaw crusher. Explain the principle, construction, and working operation of the same equipment with a suitable sketch. (3)

C) Spherical particles of cement raw material are being crushed in a lab-scale attrition mill. The average size of the feed is 1.5 cm and the crushed material is screened using standard screen series. The screen analysis data is given below. (4)

Mesh No	Average particle size (mm)	Weight of particle retained (gm)
–4 + 6	3.215	450
–6 + 8	1.197	240
–8 + 20	0.995	60
–20 + 48	0.326	90
–48 + 65	0.206	85
–65 + 150	0.185	45
–150 + 200	0.100	50

Rittinger's law constant is 0.01 J-m/gm. Calculate the (i) power required in terms of hp to crush 1 ton/hr of the cement feed material and (ii) specific surface area of the cement raw material. Assume that the density of the cement raw material is 2.67 g/cc.

3) State the difference between free and hindered settling of solid particles in a fluid medium. Develop an expression to calculate the ratio of the size of the particle in the sample mixture in various regions, if the particles are settled in equal settling velocity with appropriate graphical representation. (4)

A)

B) With a neat sketch, explain the principle, construction, and working operation of an Elutriator with its advantages. (3)

C) Urea pellets are made by spraying melted urea with cold air at the top of the tall tower and allowing the material to solidify as it falls. The pellets are 6 mm in diameter and made to fall from a 25 m height tower containing the air at 15˚C. The density of urea pellets and air are 1330 and 1.2056 kg/m^3, respectively. The viscosity of air is 0.017 mPa-sec. What would be the settling time of the urea pellets assuming that the particles settle under free-settling conditions? (3)

4) Write the effect of various factors on the rate of filtration with appropriate mathematical representation. Prove analytically that the filtrate flow rate (Q_f) varies with the speed (N) of the rotary drum vacuum filter for the formation of compressible cake. (4)

A)

B) It is desired to filter a beer containing citric acid on a continuous rotary drum vacuum filter. The filter has an area of 18.1 m^2, a negligible medium resistance, a cycle time of 75 sec, and a pressure difference of close to 1 atm. The cake that forms has a washing efficiency of only 60% but it is incompressible and permeable $\frac{\mu\alpha\rho_0}{2\Delta P} = 86\ \frac{sec}{cm^2}$. The cake retains 7% of filtrate leaving and should be washed until the cake contains only 10% citric acid originally entrained. Calculate the washing time required to process 3000 lit of beer/hr. (3)

C) Write the significance of the centrifugation coefficient and 'Z' factor during the separation of fine particles in a centrifugation operation with the relevant equation. Why the stokes region is valid to calculate the settling velocity of a particle in a centrifugation (3)

operation?

5) Briefly explain the theory of sedimentation with suitable assumptions and deduce the relationship between the concentration of solids in the rate-limiting layer (C_L) and the initial concentration of solids in slurry (C_o) (4)

A)

B) The data given below are obtained from a single batch sedimentation test on calcium carbonate ($CaCO_3$) slurry. Determine the maximum cross-sectional area and diameter required for the thickener to handle 6.67 x10^6 lit of slurry/day. The density of the pure $CaCO_3$ and water are 2.63 g/cc and 1 g/cc, respectively. If solids are from a feed concentration of 60 kg solids/m^3 of slurry to give an underflow concentration of 38.172% by weight of solids. (3)

C_L (kg/m^3)	60	70.1	95	126	160	240	330
V_L (m/hr)	1.4	1.12	0.75	0.37	0.2	0.035	0.024

where C_L= Concentrations of solids (kg/m^3); V_L = Settling rate (m/hr)

C) A continuous disc stack centrifuge is operated at 5000 rpm for the separation of fine particles. At a feed rate of 60 Lit/min, 50% of the particles are recovered. At constant centrifuge speed, solid particle recovery is inversely proportional flow rate. (a) What flow rate is required to achieve 90% particle recovery if the centrifuge speed is maintained at 5000 rpm? (b) What operating speed is required to achieve 90% recovery at a feed rate of 60 Lit/min? Assume that the settling rate remains constant. (3)

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