3/10

Quiz 1

الاسم:

Data on the mixing of sand and salt particles in an air-fluidized bed are given below. Assuming that the mixing process is first-order, calculate the time taken for the mixing index to reach 0.95. In each run, the charge to the mixer was 254.4 g salt on top of 300.0 g of sand. The average number of particles in each sample was 100.

$I = 0.95$

Data on mixing of 35/48 mesh sand in a 2 inch air-fluidized mixer											
Run no.	Mixing time (s)	x_i: Number fraction of sand in spot samples									
1	45	0.64	0.68	0.74	0.63	0.73	0.81	0.59	0.65	0.62	0.70
		0.66	0.64	0.77	0.70	0.67	0.58	0.60	0.65	0.87	0.60
		0.49	0.52	0.49	0.54	0.64	0.38	0.32	0.34	0.49	0.52
		0.25	0.32	0.33	0.35	0.48	0.23	0.16	0.32	0.44	0.39
		0.26	0.26	0.21	0.32	0.38	0.22	0.24	0.22	0.15	0.36
2	87	0.53	0.54	0.60	0.60	0.60	0.55	0.56	0.60	0.69	0.63
		0.48	0.67	0.65	0.63	0.62	0.46	0.63	0.58	0.48	0.59
		0.49	0.53	0.46	0.49	0.58	0.34	0.52	0.45	0.50	0.47
		0.42	0.35	0.43	0.49	0.59	0.38	0.39	0.45	0.52	0.39
		0.35	0.36	0.37	0.49	0.48	0.37	0.49	0.32	0.32	0.36

$t = 45 \rightarrow n = 50 \rightarrow I_1 = \frac{1}{\sqrt{n}} = \frac{1}{\sqrt{50}} = 0.14$

$I = 0.95 \qquad t = 87 \rightarrow n = 50$

$t = \frac{1}{K} \ln\left(\frac{1 - I_1}{1 - I_2}\right)$

$t = \frac{1}{K} \ln\left(\frac{1 - 0.14}{1 - 0.95}\right)$

$t = \frac{1}{K} \ln\left(\frac{0.86}{0.05}\right)$

$t = \frac{1}{K}(2.82) = \frac{2.82}{0.14}$

$t = 20.14\ s$

$\frac{dI}{dt} = K(1 - I)$

$I = Kt - It$

$I_1 = 0.14 \rightarrow t = 45\ s$

$0.14 = K(45) - 0.14(45)$

$K = 0.14$

Quiz 2

الاسم:

A ball mill 1.6 m in diameter is used to grind a limestone material from a mean particle size of 20 mm to a product of less than 1 mm. Suggest a proper condition for running the mill.

$$n_c = \frac{1}{2\pi}\sqrt{\frac{g \ m/s^2}{(R-r)m}}$$

$$= \frac{1}{2\pi}\sqrt{\frac{9.8}{1.6-0.2}}$$

$$= 0.42/s$$

8/10

Heat

Project + HW ← Thermo → 10/5

Strength → 13/5

Solid → 9/5

8/5

mid 4/5

Quiz 5

Thermo

Lab S-4

9:10 - 10:10

10:20 - 11:20

11:30 - 12:30

12:40 - 1:40

1:50 - 2:50

3 - 4

4:10 - 5:10

5:20 - 6:20

12:40 - 1:40

10:10 - 9:10

9:1

8-9

9:10 - 10:10

10:20 - 11:20

11:30 - 12:30

12:40 - 1:40

1:50 - 2:50

3 - 4

6/10

14/20

University of Jordan
Chemical Engineering Dept.
Operations of Solid Particulates

First Exam

Q1 Answer the following questions: Time: one hour

Date:

Q 1. a) Mention two types of agglomeration mechanisms.

electrostatic ① effect of Temp. ② wedling plastic

③ interLocking and attraction Between The particle.

b) Briefly explain the mechanism of size reduction.

① Crusher, ② grinding ③ comminution

The mechanisim is To increase the surface Area To make The reaction we need and To mixing The particle

c) Explosive material must be crushed dry and in the presence of inert atmosphere.

Is it (a) true or (b) false ?

d) Is the Ball mill coarse crusher or intermediate crusher or fine crusher? intermediate crusher

e) Define: fin.

(1) Angle of Repose Low angle Repose at high density.

the Angle Between the horizantal surface and The inclined surface which The particle slide

(2) Angle of nip.

$\tan\alpha = 2\%$ correction Factor

α is The angle Between The particle and The moving Jaw. ??

الزاوية التي تعمل الجزيئات مع Horizantal

f) Find the sphericity of a solid particle with the following dimensions:

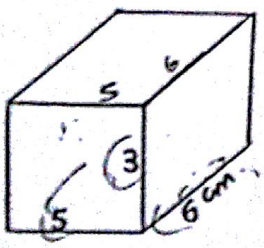
volume $= 6 \times 3 \times 5 = 90\ cm^3$

volume of sphere $= \frac{\pi}{6} D^3 = 90 \rightarrow D = 5.56\ cm$

surface area of sphere $= 4\pi \left(\frac{5.56}{2}\right)^2 = 97.12\ cm^2$

surface area of sphere $= 2 \times 3 \times 5 + 2 \times 6 \times 3 + 2 \times 6 \times 5$

$= 126\ cm^2$



$\psi = \frac{97.12}{126} = 0.77$

g) What is meant by pneumatic conveying. تفريغ

① bucket ② belt

particle are transported in astream of air and water

h) Mention the Mechanisms of solid mixing.

① Diffusion mixing, or Diffusion.

② shear mixing

③ Convection mixing : is change the position of the particle To another position.

f)

$\epsilon = \frac{\text{surface area of spher as volume of particle}}{\text{surface area of particle}}$

$V_p = V_{sphere}$ $\qquad V_{spher} = \frac{1}{6}\pi d_v^3$

$6 * 3 * 5 = \frac{1}{6}\pi d_v^3$

$d_v = 5.56$ cm of spher

$\epsilon = \frac{\pi \cdot d_v^2}{\text{surface Area of particle}}$

Surface Area of particle =

$5*3*2 + 6*3*2 + 5*6*2 = 126 \text{ cm}^2$

$\epsilon = \frac{\pi * (5.56)^2}{126} = \cancel{0.77}$

$= 0.77$

طالب: [redacted]

اسم الطالب: [redacted]

8/10

Q5

2. (a) 3.5 kw has to be supplied to a machine crushing material at the rate of 0.5 kg/s from 14mm particle size to a product having the following sizes:

5%	2.5 mm
15%	2.75 mm
80%	3.25 mm

What would be the power required to crush 0.5 kg/s of the same material from 8.0 mm to produce a product with particle size of 2mm (use Bond's law).

3.5 Kw → 0.5 Kg/s

? → 0.5 Kg/s

$$\boxed{\frac{3.5 * 0.5}{0.5} = 3.5 \text{ Kw}}$$

$$E = E_i \sqrt{\frac{100}{L_2}} \left\{ 1 - \frac{1}{q^{\frac{1}{2}}} \right\}$$

First To calculate The power we must calculate the d_v

$$d_v = \sum x_i d_i$$

$$= 2.5 \times .05 + 2.75 \times .15 + 3.25 \times .80$$

$$= 3.14 \text{ mm}$$

$$q = \frac{L_1}{L_2} = \frac{14 \text{ mm}}{3.14 \text{ mm}} = 4.458$$

$$3.5 = E_i \sqrt{\frac{100}{3.14}} \left\{ 1 - \frac{1}{(4.458)^{\frac{1}{2}}} \right\}$$

$$E_i = 1.178 \text{ Kw.s/Kg}$$

For The particle 8.0 to 2mm:

$$q = \frac{L_1}{L_2} = \frac{8}{2} = 4 \text{ mm}$$

$$E = 1.178 \sqrt{\frac{100}{2}} \left\{ 1 - \frac{1}{(4)^{\frac{1}{2}}} \right\}$$

$$\boxed{E = 4.16 \text{ Kw}}$$

5/5

(b) Calculate the settling velocity of a glass ~~shere~~ sphere having a diameter of 55.4 μm in water at 293.2 K. The density of glass= 2067 kg/m³ and the viscosity of Water = 1.0 m N.s/m².

$Re = \frac{\rho v D}{\mu}$

$\frac{R_o'}{\rho u_o'}$, $Re_o^2 = \frac{2 d_p^3 (\rho_p - \rho_f) \rho_f g}{3 \mu^2}$

$C_D Re_o^2 = \frac{2 * (55.4 * 10^{-6})^3 (2067 - 1000) 1000 * 9.8}{3 * (1 * 10^{-3})^2}$

$C_D Re_o^2 = 1.1865$

$\log 1.1865 = .0743 \approx 0.1$

then we go To Table 3.4

make interpolation

0.0	2.908
0.0743	log Re
0.1	1.007

$\frac{0.1 - 0.0}{0.1 - 0.0743} = \frac{1.007 - 2.908}{1.007 - R}$

log Re

$\log Re = 1.49$

$u_o = \frac{1.49 * 1 * 10^{-3}}{1000 * (55.4 * 10^{-6})}$

$u_o = .027 \, m/s$

$Re = \frac{\rho u_o d}{\mu}$

$u_o = \frac{Re * \mu}{d \rho}$

3/5

6.25/20

University of Jordan
Chemical Engineering Department
Operations of solid particulates
2010/2011
2nd exam

الاسم:
الرقم:

Answer the following questions — **Time: one hour**

Question one A packed bed of non-spherical solids of density 2000kg/m^3 occupies a depth of 0.6 m in a cylindrical vessel of inside diameter of 10 cm. The mass of solids in the bed is 5 kg and the surface mean diameter of the particles is 300μm. Water flows upwards through of the bed. [μ_{water} =1.0 mN/s/m^2 , ρ_{water}=1000kg/m^3].

Calculate:

i. The average liquid velocity through the pores at which the pressure drop across the bed is 4130 Pa.
ii. The specific surface area of the solid particles.
iii. The regime of flow at condition given in part (i).

Calculate e??

$e = 0.45$

$u_c = \frac{1}{180}\frac{e^3}{(1-e)^2}\frac{(-\Delta P\, d_s)}{\mu_L}$

$= \frac{1}{180}\frac{(0.45)^3}{(1-0.45)^2}\left(\frac{4130(300\times10^{-6})}{1\times0.6}\right)$

$= 3.4\times10^{-3}$

units μ

$S = \frac{\text{surface area}}{\text{vol}} = \frac{6}{d_s} = \frac{6}{0.3\times10^{-3}} = 20\times10^3$

$S = \frac{6}{d_s}$

$A_s = \pi D^2$

Fluidization

$u_{mf} = 0.0055\left(\frac{e_{mf}^3}{1-e_{mf}}\right)\frac{d^2(\rho_s-\rho)g}{\mu}$

$= 0.0055\left(\frac{0.45^3}{0.55}\right)\left(\frac{0.1^2(1000)9.8}{1}\right) = 0.089$

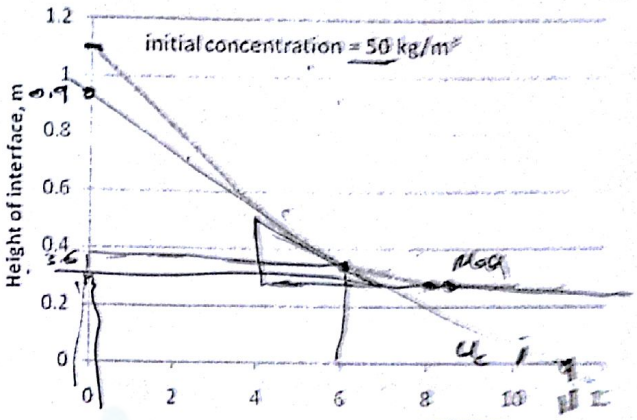
$Ga = \frac{d^3\rho(\rho_s-\rho)g}{\mu} = 0.1(1000)(1000)9.8 = 0.98\times10^6$

3.5/10

2.75/10

Question two

a) For the given sedimentation curve,
   1. calculate the settling velocity and the solid flux at time = 6 hr.
   2. what is the maximum concentration of the slurry.



0.5

1. $u_c = \frac{h}{t} = \frac{3.6}{6hr} \cdot \frac{1hr}{3600s} = 1.667 \times 10^{-4}$ m/s

$C = C_0 \frac{1.1}{0.3}$

2. $C_{max} = C_0 \frac{\Delta H_1}{\Delta H_2}$

$= 50\left(\frac{0.5-0.3}{7-4}\right) = 50\left(\frac{0.2}{3}\right) = 3.3$ kg/m²

$u_c = \frac{0.9}{11}$

$C = 50 \times \frac{1.1}{3.6}$

$\psi = u_c \times C$

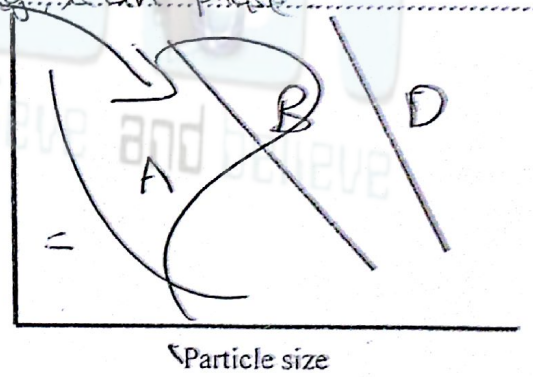
b) In case of coarse sedimentation and for high velocities, $Re_0' > 500$, R_0' is independent of size but for low velocities, $Re_0' < 0.2$, R_0' is independent of size and shape. Hence, $\frac{u}{u_0}$ is only function in ρ.

c) What do we mean by the discontinuous phase in case of aggregative fluidized bed.
bubbling lean phase

d) Write on the graph the 4 categories that classify the powder materials and which one the difficult is to fluidize.

0.25

size (μm)
A (30 - 100) → low velocity specified,
B (100 - 800)
C (20) ...
D (1000) → difficult is to fluidize



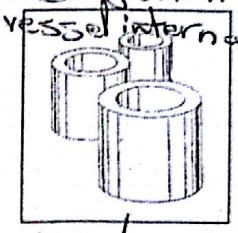
e) Mention 3 factors that affect the size of bubbles and solid mixing in fluidized bed.

1. velocity of the fluid
2. voidage
3. size of particles

1. type of gas distributer
2. solid and fluid properties.
3. bed geometry
4. gas flow rate

f) Write the name of each packing given in adjacent figures.

4. vessel internals
1. screen
2. baffles
3. heat ex



Ring packing

Rashig

Rach

Less enc

$S = \frac{6}{D} = 6 / 3\times10^{-3} = 2\times10^{3}$

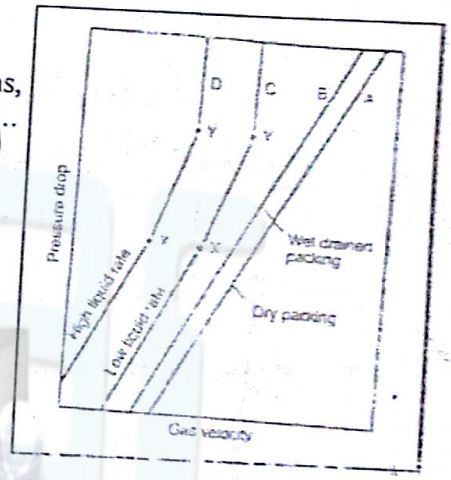
g) A bed consists of uniform spherical particles of diameter 3 mm and density 4200 kgm^{-3}. What will be the pressure gradient at minimum fluidization conditions if the particles were fluidized in a liquid of viscosity 3 mNsm^{-2} and density 1100kgm^{-3}? (Assume min fluidization voidage = 0.4)

$$\frac{\Delta P}{L} = \frac{S}{6} g (1-e)(\rho_s - \rho)$$

$$= (3\times10^{-3})(9.8)(1-0.4)(4200-1100)\frac{6}{3\times10^{-3}}$$

h) (1) The point X in the graph means ~~Loading~~ ..... but point Y means ~~Flooding~~ .....

(2) It is not practicable to operate under ..... conditions, and columns are best operated over section ~~wet packing~~ ~~drained~~



8.5/30

University of Jordan
Chemical Engineering Department
Solid Particulates
2010/2011
Mid-term exam

الاسم:
الرقم:

Answer the following questions

Time: one hour

Q1.

Question	Answer
a) If the coefficient of friction for crushing rolls is 0.28, find the angle of nip.	$\mu = 0.28$ find nip angle = ? $\tan\alpha = \mu \Rightarrow \alpha = \tan^{-1}\mu = 15.6$
b) What is meant by soapiness? If it has a low value, what do you expect to happen to crushing process?	~~increase~~ wet particle ~~increase~~ increase the ~~crushing~~ process
c) What does the mixing index show?	the able of machine to mix materiales.
d) Consider a cylindrical solid particle of length 1.0 mm and diameter 0.1 mm; calculate the sphericity, the sieve diameter, and the projected area diameter.	$L = 1$, $d = 1$, sphere = 1? sphericity = 0? projected area diameter $2\left(\frac{\pi d^2}{4}\right) + \pi d l$? $2\pi\left(\frac{0.1*10^{-3}}{2}\right)^2 + \pi \times 0.1*10^{-3} \times 1*10^{-3}$ $= 1.7*10^{-7}$? Sieve diameter. $2/2^{1/2}/2^{1/4}$ $2*0.1*10^{-3} = 0.2*10^{-3}$ $2^{1/2}*0.1*10^{-3} = 0.14*10^{-3}$ $2^{1/4}*0.1*10^{-3} = 0.12*10^{-3}$

1/10

Q2. It is desired to crush 9080 kg/h of iron ore hematite. The size of the feed is such that 80% passes a 76.2 mm screen and 80% of the product is to pass a 3.175 mm screen. The work index is 0.0503 $kWm^{0.5}/(kg/s)$.

1. Calculate the power required in kW.
2. Calculate the power required (in kW) to crush the product further where 80% is less than 1000 μm.

size

Feed 0.8 → 76.2 → 0.01

prod 0.8 → 3.175 → 0.2

Feed 0.2 → 3.175 → 0.06

prod 0.2 → 76.2 → 0.0

$W = C_f\left(\frac{1}{L_2} - \frac{1}{L_1}\right) =$

$\frac{0.8}{76.2} = 0.01$

$\frac{0.8}{3.175} = 0.2$

$\frac{0.2}{3.175} = 0.06$

$\frac{0.2}{76.2} = 2.6 * 10^{-3}$

$W = C_f\left(\frac{1}{L_2} - \frac{1}{L_1}\right) =$

$0.0503\ kWm^{0.5}$

$0.0503 = C_f\left(\frac{1}{0.003175} - \frac{1}{0.0762}\right)$

$C_f = 1.67 * 10^{-4}$

$W = 1.67 * 10^{-4}$

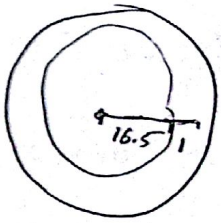
$P = 0.0503\ kWm^{0.5}/s \cdot \frac{9080\ kg}{h} \cdot \frac{h}{3600\ s}$

$= 0.127\ kWm^{0.5}$

$P = \frac{L_2}{L_1} = \frac{1000}{76.2} \leq 13.12\ kW$

1/10

Q3. A finely divided sample of water and insoluble organic pigment of density 1425 kg/m^3 was thoroughly dispersed in water and the suspension transferred to a centrifuge tube. The surface of the liquid in the tube was 16.5 cm from the axis of rotation of the centrifuge.
After centrifuging for 360 s at 360 revolutions per minute a pipette was lowered into the centrifuge tube and a small sample of the suspension withdrawn from 1.0 cm below the surface.
Determine the particle size of the organic pigment which was suspended in this sample.
Density of water = 998 kg/m^3, Viscosity of water = 1.24 mN s/m^2



$h = R - r_0$

$= 17.5 - 16.5$

$= 1\,cm / 100\,cm = 0.01\,m$

? Assume Stokes Regime

$F = \frac{18 \mu h}{d^2 w^2 (\rho_s - \rho) R}$

$\omega = 2\pi n = 2\pi (360) / 60\,s = 37.7\ rev/s$

$= \frac{18 (1.24 \times 10^{-3}) \times 0.01}{d^2 (37.7)^2 (1425 - 998)(17.5)}$

$= 360$??

cm units

$d^2 = 5.8 * 10^{-11}$

$d = \sqrt{5.8 * 10^{-11}} = 7.6 * 10^{-6}\ m$

find velocity then Check Regime ??

Re

$\frac{6}{\pi D}$

$$Q = \frac{250\ cm^3}{12\ min \times \frac{60\ s}{1\ min} + 54\ s} = 0.32\ cm^3/s \times \frac{1\ m^3}{(100\ cm)^3}$$

$$= 0.32 \times 10^{-6}\ m^3/s$$

$$e = 1 - \frac{\text{vol. of solids}}{\text{total vol.}}$$

$$\text{vol. of solids} = \frac{25.4 \times 10^{-3}\ kg}{3100\ kg/m^3} = 8.19 \times 10^{-6}\ m^3 \qquad V = \frac{m}{\rho}$$

$$\text{vol of Cell (total vol)} = \frac{\pi}{4}(2.5 \times 10^{-2})^2 (2.73 \times 10^{-2}) = 1.34 \times 10^{-5}\ m^3$$

$$V_{Tot} = \frac{\pi}{4} d^2 L$$

$$e = 1 - \frac{8.19 \times 10^{-6}}{1.34 \times 10^{-5}} = 0.39$$

$$\Delta P = \rho_{Hg}\, g h$$

$$= \frac{13600\ kg}{m^3} \times 9.8\ \frac{m}{s^2} \times -12.5\ cm \times \frac{1\ m}{100\ cm}$$

$$= -16660\ \frac{kg}{m.s^2} \times \frac{1\ N}{1\ \frac{kg.m}{s^2}} = -16660\ N/m^2\ (Pa)$$

$$u = \frac{3.2 \times 10^{-7}}{\frac{\pi}{4}(2.5 \times 10^{-2})^2} = 8.42 \times 10^{-4}\ m/s \qquad u = \frac{Q}{A}$$

$$u = \frac{1}{180} \frac{e^3 d^2}{(1-e)^2 \mu} \frac{(-\Delta P)}{L}$$

$$8.42 \times 10^{-4} = \frac{1}{180} \frac{(0.39)^3 d^2}{(0.61)^2 \times 1.82} \times \frac{16660}{2.73 \times 10^{-2}}$$

$$d^2 = 2.8 \times 10^{-12}$$

$$d = 1.68 \times 10^{-6}\ m = 1.68\ \mu m$$

1 (a) Determin $d_v = \Sigma x_i d_i$, Σ weight = 100

average size	x_i	$x_i d_i$	$1/(x_i/d_i^3)$
0.099	0.053	5.247×10^{-3}	54.62
0.05	0.078	3.9×10^{-3}	624
0.027	0.175	4.275×10^{-3}	8891
0.015	0.295	$K \times 4.425 \times 10^{-3}$	87407
0.008	0.221	1.768×10^{-3}	131640.475
0.005	0.126	6.3×10^{-4}	1008000
0.003	0.042	1.26×10^{-4}	1555555
0.001	0.01	1×10^{-5}	10^7
			13092112.75

$K \times 1.2$

$d_v = \Sigma x_i d_i = k \times 0.02$ mm

$= 1.2 \times 0.02 = 0.024$

(b) mean $d_{v'} = \sqrt[3]{\dfrac{1}{\Sigma(x_i/d_i^3)}} = \sqrt[3]{\dfrac{1}{\Sigma \dfrac{x_i}{k^3 d_i^3}}} = \sqrt[3]{\dfrac{1}{k^3 \Sigma \dfrac{x_i}{d_i^3}}}$

$= \sqrt[3]{\dfrac{1}{k^3}} \times \sqrt[3]{7.64 \times 10^8} = \sqrt[3]{\dfrac{1}{(1.2)^3}} \times 4.24 \times 10^{-3} = 3.53 \times 10^{-3}$

(c)

size	accumulated Frequency	
0.099	5.3	0.053
0.05	5.3 + 7.8 = 13.1	0.131
0.027	13.1 + 17.5 = 30.6	0.306
0.015	60.1	0.601
0.008	82.2	0.822
0.005	94.8	0.948
0.003	99	0.99
0.001	100	1

22 a $d_A = 0.4\ mm$, $d_B = 0.9\ mm$.

21 what is the Ratio of U_{oA} / U_{oB}.

- stoke $F = 3\pi\mu u_o d$ $F_G = \frac{\pi}{6} d^3 (\rho_s - \rho) g$

$F = F_G$

$3\pi\mu u_o d = \frac{\pi}{6} d^3 (\rho_A - \rho) g$

$U_{oA} = \frac{d_A^2 \cdot g (\rho_A - \rho_w)}{18\mu}$

$\rho_A = \rho_B$

$U_{oB} = d_B^2 \frac{g (\rho_B - \rho_w)}{18\mu}$

$\frac{U_{oA}}{U_{oB}} = \frac{d_A^2 \times \cancel{\theta}}{d_B^2 \times \cancel{\theta}} \Rightarrow \frac{U_{oA}}{U_{oB}} = \left(\frac{0.4\ mm}{0.9\ mm}\right)^2 = 0.198$

- Newtons Region

$\frac{R'}{\rho u^2} = 0.05$, $F = R' * Area = 0.05 \times \rho_w U_o^2 \times \frac{\pi}{4} d^2$

$F_G = \frac{\pi}{6} d^3 (\rho_s - \rho) g$

$U_{oA}^2 * 0.05 * \rho_w * \frac{\pi}{4} d_A^2 = \frac{\pi}{6} d_A^3 (\rho_A - \rho) g$

$U_{oA}^2 = \frac{4 d_A (\rho_A - \rho) g}{6 * 0.05 * \rho_w}$

$U_{oB}^2 = \frac{4 d_B (\rho_B - \rho) g}{6 * 0.05 * \rho_w}$

$\frac{U_{oA}^2}{U_{oB}^2} = \frac{d_A * \cancel{\theta}}{d_B * \cancel{\theta}} \Rightarrow \left(\frac{U_{oA}}{U_{oB}}\right)^2 = \frac{d_A}{d_B}$

$\frac{U_{oA}}{U_{oB}} = \sqrt{\frac{0.4}{0.9}} = \frac{2}{3}$

(b) Both

• in Stok Region $\frac{U_{oA}}{U_{oB}} = 0.198$

$\Rightarrow U_{oB} = 1\ m/s \Rightarrow U_{oA} = 0.198$

$$U_{oA} = \frac{d_A^2\, g(\rho_A - \rho)}{18\mu} = \frac{(0.4\times10^{-3})^2 * 9.81 * (2750 - 1000)}{18 * 0.001}$$

$= 0.1526$

$$U_{oB} = \frac{d_B^2\, g(\rho_B - \rho)}{18\,\mu} = \frac{(0.9\times10^{-3})^2 * 9.81 * (2750 - 1000)}{18 * 0.001} = 0.7725$$

100% Removal

So $U_{oB} = 0.7725$

$\frac{U_{oA}}{U_{oB}} = 0.198 * 0.7725 = 0.1526$ $\Rightarrow$ also $U_{oA} = 100\%$

• For Newton Region $\frac{U_{oA}}{U_{oB}} = \frac{2}{3}$

$$U_{oB}^2 = \frac{4 d_B\, (\rho_B - \rho) g}{6 * 0.05 * \rho} = \frac{4 * 0.9\times10^{-3} * (2750 - 1000) * 9.81}{6 * 0.05 * 10^3}$$

$= 0.20601 \Rightarrow U_{oB} = 0.454\ m/s$

100% Removal

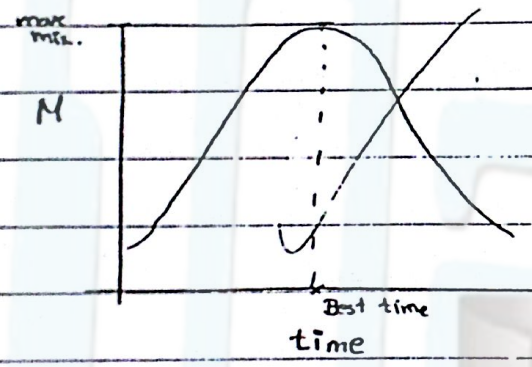
$$U_{oA}^2 = \frac{4 * 0.4\times10^{-3} * 1750 * 9.81}{6 * 0.05 * 10^3} \Rightarrow U_{oA} = 0.302$$

100% Removal

(c) $\psi = \frac{6 * \frac{\pi}{6} D^3}{D_p * \pi D^2} = \frac{D}{D_p}$ = ~~volume of circle as~~

$\psi = \frac{6 * \frac{\pi}{6} D^3}{}$

(3) (a) Draw the of M with time



(b) List nature of material to Be crushed.

1- hardness :- with hard material use low speed crusher and the hardness is determined By mohr scale.

2- ~~streng~~ crushing strength : as it increase power is increase for ~~cr~~ crushing.

3- stickness :- when the material stick we should use machine which can be cleaned easily

4- soapness

5- Friability : tendency of material to fracture.

6- Explosion :- material which are explosive should be crushed with an inert of atmosphere.

7- ~~diameter of the particle~~ Moisture content

8- structure

University of Jordan
Department of Chemical Engineering
95442 Unit Operation of Particulate Solids

Homework No.1

1. The following table gives the size distribution of a dust as measured by the microscope. Convert these figures to obtain the distribution on a weight basis, and calculate surface mean diameter and the specific surface, assuming spherical particles of specific gravity 2.65.

Size range in um	Number of particles in range
0-2	2000
2-4	600
4-8	140
8-12	40
12-16	15
16-20	5
20-24	2

$\frac{\mu m^2}{\mu m^3}$ = sp. surface

Q2. A crusher in reducing limestone of crushing strength 70 MN/m^2 from 6 mm diameter average size to 0.1 mm diameter average size requires 9 kW. The same machine is used to crush dolomite at the same rate of output from 6 mm diameter average size to a product which consists of 20% with an average diameter of 0.25 mm, 60% with an average diameter of 0.125 mm, the balance having an average diameter of 0.085 mm. Estimate the power required to drive the crusher, assuming that the crushing strength of the dolomite is 100 MN/m^2 and that crushing follows Ritinger's law.

Use the weight mean diameter in you calculation

Use % as numbers not x

University of Jordan

Department of Chemical Engineering

95442 Unit Operation of Particulate Solids

Homework No. 1

1. The following table gives the size distribution of a dust as measured by the microscope. Convert these figures to obtain the distribution on a weight basis, and calculate surface mean diameter and the specific surface, assuming spherical particles of specific gravity 2.65.

Size range in um	Number of particles in range
0-2	2000
2-4	600
4-8	140
8-12	40
12-16	15
16-20	5
20-24	2

Q2. A crusher in reducing limestone of crushing strength 70 MN/m^2 from 6 mm diameter average size to 0.1 mm diameter average size requires 9 kW. The same machine is used to crush dolomite at the same rate of output from 6 mm diameter average size to a product which consists of 20% with an average diameter of 0.25 mm, 60% with an average diameter of 0.125 mm, the balance having an average diameter of 0.085 mm. Estimate the power required to drive the crusher, assuming that the crushing strength of the dolomite is 100 MN/m^2 and that crushing follows Ritinger's law.

Use the weight mean diameter in your calculation

Hw 2

Q1 :- $D = 2\,mm$ $\rho_s = 7870\ kg/m^3$

$\rho_p = 900\ kg/m^3$ $\mu = 50\ mNs/m^2$

$$\rightarrow \frac{R_o'}{\rho u_o^2} Re'^2 = \frac{2}{3}\frac{d^3}{\mu^2}\rho(\rho_s-\rho)g$$

$$= \frac{2}{3}\frac{0.002^3}{0.05^2}\,900(7870-900)\,9.81$$

$$= 131.3$$

$$\log 131.3 = 7.118$$

From table 3.4 $\rightarrow$ $\log Re_o' = 0.833$

$$Re_o' = 6.8$$

$$u_o = 6.8 \times 0.05 / 900 \times 0.002 = \boxed{0.189\ m/s}$$

Q2 :-

$$y = \frac{b}{a}t - \frac{b}{a^2}(1-e^{-at})$$

$$b = g\left(1-\frac{\rho}{\rho_s}\right) = 9.81\left[1-\left(\frac{1000}{2650}\right)\right] = 6.108\ m/s^2$$

$$a = \frac{18\mu}{d^2\rho_s} = \frac{18 \times 1.2\times10^{-3}}{(20\times10^{-6})^2 \times 2650} = 203775^{-1}$$

$y = 180\ mm$ or $0.18\,m$

$$\rightarrow 0.18 = \frac{6.108}{203775}t - \frac{6.108}{(203775)^2}(1-\exp(-203775t))$$

$\hookrightarrow$ neglected

$$t = \frac{0.18}{0.0003} = \boxed{600\,s}$$

University of Jordan
Department of Chemical Engineering
Unit Operation of Particulate Solids
H.W. No. 3

Q1. In a contact sulphuric acid plant the secondary converter is a tray type converter, 2.3 m in diameter with the catalyst arranged in three layers, each 0.45 m thick. The catalyst in is the form of cylindrical pellets 9.5 mm in diameter and 9.5 mm long. The void fraction is 0.35. The gas enters the converter at 675 K and leaves at 720 K. Its inlet composition is

SO_3 6.6, SO_2 1.7, O_2 10.0, N_2 81.7 mol%

and its exit composition

SO_3 8.2, SO_2 0.2, O_2 9.3, N_2 82.3 mol%

The gas flow rate is 0.68 kg/m^2s. Calculate the pressure drop through the converter by using carman method.

$\mu = 0.032$ m Ns/m^2

Q2. A column 0.6 m diameter and 4 m tall, packed with 25 mm ceramic hollow packings is used in a gas absorption process carried out at atmospheric pressure and 293 K. If the liquid and gas can be considered to have the properties of water and air, and their flow rates are 6.5 and 0.6 kg/m^2 s respectively, what will be the pressure drop across the column ?

Use Carman's method,

Data: Specific Surface of packing $S = 656\ m^2/m^3$
mean voidage of bed $e = 0.71$
Viscosity of vapor $\mu = 0.018$ m Ns/m^2
Kilogram molecular volume $= 22.4\ m^3/kmol$.

/SA.

3/10

Quiz 1

الاسم:

Data on the mixing of sand and salt particles in an air-fluidized bed are given below. Assuming that the mixing process is first-order, calculate the time taken for the mixing index to reach 0.95. In each run, the charge to the mixer was 254.4 g salt on top of 300.0 g of sand. The average number of particles in each sample was 100.

$I = 0.95$

N

$W = \frac{254.4}{554.4} = 0.4589$

Data on mixing of 35/48 mesh sand in a 2 inch air-fluidized mixer												
Run no.	Mixing time (s)	x_i: Number fraction of sand in spot samples										
1	45	0.64	0.68	0.74	0.63	0.73	0.81	0.59	0.65	0.62	0.70	50 sample
		0.66	0.64	0.77	0.70	0.67	0.58	0.60	0.65	0.87	0.60	
		0.49	0.52	0.49	0.54	0.64	0.38	0.32	0.34	0.49	0.52	
		0.25	0.32	0.33	0.35	0.48	0.23	0.16	0.32	0.44	0.39	
		0.26	0.26	0.21	0.32	0.38	0.22	0.24	0.22	0.15	0.36	
2	87	0.53	0.54	0.60	0.60	0.60	0.55	0.56	0.60	0.69	0.63	50 sample
		0.48	0.67	0.65	0.63	0.62	0.46	0.63	0.58	0.48	0.59	
		0.49	0.53	0.46	0.49	0.58	0.34	0.52	0.45	0.50	0.47	
		0.42	0.35	0.43	0.49	0.59	0.38	0.39	0.45	0.52	0.39	
		0.35	0.36	0.37	0.49	0.48	0.37	0.49	0.32	0.32	0.36	

$\bar{x}_{45} = \frac{\sum x_i}{N} = 0.483$

$\sum (x_i - \bar{x})^2 = 1.80945$

$I_{45} = \left\{ \frac{(\overset{50}{N}-1)\overset{0.4589}{M}(1-M)}{\underset{100}{n} \underset{1.80945}{\sum (x_i - \bar{x})^2}} \right\}^{0.5}$

$I_{45} = 0.19277435$

$\bar{x} = \frac{\sum x_i}{N} = 0.4966$

$\sum (x_i - \bar{x})^2 = 0.498722$

$I_{87} = \left\{ \frac{(\overset{50}{N}-1)\overset{0.4589}{M}(1-M)}{\underset{100}{n} \underset{0.498722}{\sum (x_i - \bar{x})^2}} \right\}^{0.5}$

$I_{87} = 0.6994188121$

$t_{87 \to 45} = 87 - 45 = \frac{1}{k} \ln\left(\frac{1 - 0.1927\ldots}{1 - 0.6994\ldots}\right) \to k = 0.0233284912 6$

$t_{new} \to t_{n-87} = t_{new} - 87 = \frac{1}{k} \ln\left(\frac{1 - 0.6997188121}{1 - 0.95}\right) \to t_{new} = 100.126\ldots$

Quiz 2

الاسم:

A ball mill 1.6 m in diameter is used to grind a limestone material from a mean particle size of 20 mm to a product of less than 1 mm. Suggest a proper condition for running the mill.

$$N_c = \frac{1}{2\pi}\sqrt{\frac{g}{r}}$$

$g \rightarrow 9.81\ m/s^2$

$r \rightarrow (R - r) = (0.8 - 0.02)$

R: mill $= \frac{1.6}{2} = 0.8\ m$

r: material $= 20\ mm = 0.02\ m$

$$N_c = \frac{1}{2\pi}\sqrt{\frac{9.81}{(0.8-0.02)}} = 0.5644\ s^{-1} = 0.5644\ Hz$$

$1\ Hz = 60\ rpm$

$0.5644\ Hz \rightarrow \boxed{33.864\ rpm}$

6/10

University of Jordan
Chemical Engineering Dept.
Operations of Solid Particulates

14/20

First Exam

Q1 Answer the following questions: Time: one hour

Date:

Q 1. a) Mention two types of agglomeration mechanisms.

1) Mecanical inter locking
2) Surface attraction
3) Plastic welding
4) Electrostatic
5) moisture
6) Temperature fluctuation

b) Briefly explain the mechanism of size reduction.

*) Applied a mechanical force to break down large particles into smaller ones, such as in crushing the solid particles are subjected to external forces that cause them to break into smaller fragments. Over all the mechanism depend on type of prosses and solid properties.

c) Explosive material must be crushed dry and in the presence of inert atmosphere.
Is it (a) true or (b) false ?

d) Is the Ball mill coarse crusher or intermediate crusher or fine crusher? It is specifically designed for milling & grinding Purposes.

e) Define:

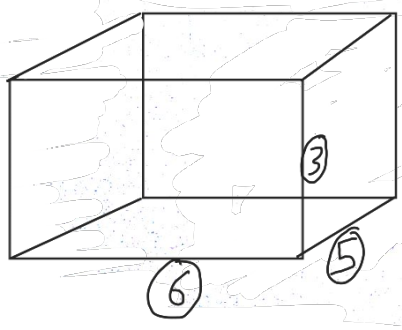
(1) Angle of Repose

*) it is the angle between the horizontal plane and the sleepest slope that a pile of material can maintain without sliding down hill.

(2) Angle of nip.

*) it is the angle between the two jaws of a crushing machine.

Find the sphericity of a solid particle with the following dimensions:



$V_p = 3 \times 5 \times 6 = 90\ mm = V_s$

$d_v = \sqrt[3]{\frac{6 V_p}{\pi}} = \sqrt[3]{\frac{6 \times 90}{\pi}} = \boxed{5.6\ mm}$

$S_A = 2(3\times5) + 2(3\times6) + 2(6\times5) = \boxed{126\ mm}$

$\phi = \frac{6 V_p}{S_p D_s} = \frac{6 \times 90}{126 \times 5.6} = \boxed{0.7653}$

g) What is meant by pneumatic conveying.

*) is a method of transporting materials such as Powders, granules...

*) Using an injection fluid (air) + solid

*) in ratio where air > solid → can't be thick.

h) Mention the Mechanisms of solid mixing.

1) Convective mixing.

2) Diffusion mixing.

3) Shear mixing.

[redacted]

8/10

Q5

2. (a) 3.5 kw has to be supplied to a machine crushing material at the rate of 0.5 kg/s from 14mm particle size to a product having the following sizes:

5%	2.5 mm
15%	2.75 mm
80%	3.25 mm

What would be the power required to crush 0.5 kg/s of the same material from 8.0 mm to produce a product with particle size of 2mm (use Bond's law).

$$d_r = \sum x_i s_i = (2.5 \times 0.05) + (2.75 \times 0.15) + (3.25 \times 0.8)$$

$$d_r = \boxed{3.1375 \text{ mm}}$$

$$q = \frac{L_1}{L_2} = \frac{14\text{mm}}{3.1375\text{mm}} = \boxed{4.462}$$

$$\underbrace{E_i}_{3.5\ \text{Kw}} = E_i \sqrt{\frac{100}{\underbrace{L_2}_{3.1375\ \text{mm}}}} \left(1 - \frac{1}{\sqrt{\underbrace{q}_{4.462}}}\right)$$

$$\boxed{\therefore E_i = 1.773 \text{ Kw}}$$

$$E_{new} = E_i \sqrt{\frac{100}{\underbrace{L_2}_{2\ \text{mm}}}} \left(1 - \frac{1}{\sqrt{q}}\right) \qquad q = \frac{8\text{ mm}}{2\text{ mm}} = 4$$

$$E_{new} = 1.773 \sqrt{\frac{100}{2}} \left(1 - \frac{1}{\sqrt{4}}\right) = \boxed{6.2685 \text{ Kw}}$$

(b) Calculate the settling velocity of a glass ~~shere~~ sphere having a diameter of 55.4 μm in water at 293.2 K. The density of glass= 2067 kg/m³ and the viscosity of Water = 1.0 m N.s/m².

by Stoke's low:

$$U_{settling} = \frac{d^2 g}{18\mu}(\rho_p - \rho_f) =$$

$d \to 55.4\times10^{-6}$ m, $g \to 9.81$ m/s², $\rho_p \to 2067$ kg/m³, $\rho_f \to$ @ 293.2 K = 1000 kg/m³, $\mu \to 1$ mN.s/m²

$$\boxed{U_{settling} = 1.78\times10^{-6}\ m/s}$$

$$Re = \frac{\rho D U}{\mu} = \frac{2067 \times 55.4\ \mu m \times 1.78\times10^{-6}}{1.0\ mN.s/m^2} = \boxed{0.0020} < 1$$

∴ laminar flow.

$$CD = \frac{18\pi \mu D}{U(1+0.15)\sqrt{Re}}$$

$D \to 55.4\times10^{-6}$, $U \to 1.78\times10^{-6}$, $\mu \to 1$ mN.s/m², $Re \to 2\times10^{-2}$

$$\boxed{CD = 0.44}$$

*) our Assumed (laminar) has accure

Maby Rong

OR

$$\frac{R_0}{\rho U_0^2} Re_0'^{-2} = \frac{2d^3(\rho_s - \rho_f)\rho_f g}{3\mu^3} = \frac{2(55.4\times10^{-6})^3 (2067-1000)\, 2067\times9.81}{3(1\times10^{-3})^2} = 2.4525\ldots$$

$$\log(R'/\rho u) Re'^2 = 0.3896119 \approx 0.390 \quad \boxed{\text{from } 3.4}$$

$$\log Re = 2.106 \to \boxed{Re = 127.64}$$

$$Re = \frac{\rho U D}{\mu} \to U = \frac{Re\,\mu}{\rho D} = \frac{127.64 \times 1\times10^{-3}}{2067 \times 55.4\times10^{-6}} = \boxed{1.115\ m/s}$$

8.5/30

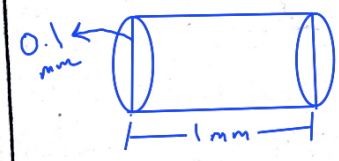
University of Jordan
Chemical Engineering Department
Solid Particulates
2010/2011
Mid-term exam

الاسم:
الرقم:

Answer the following questions

Time: one hour

Q1.

Question	Answer
a) If the coefficient of friction for crushing rolls is 0.28, find the angle of nip.	friction coeff = tan θ ↳ angle of nip $\theta = \tan^{-1}(0.28) = \boxed{15.64^\circ}$
b) What is meant by soapiness? If it has a low value, what do you expect to happen to crushing process?	the tendency of a material to creat a soapy or slippery film on the crushing surfaces, which can reduce the efficiency of the crushing process.
c) What does the mixing index show?	the mixing rate → the distance from the mixture to the perfect mixture.
d) Consider a cylindrical solid particle of length 1.0 mm and diameter 0.1 mm; calculate the sphericity, the sieve diameter, and the projected area diameter.  $\boxed{\varphi = \frac{SA_s}{SA_p}}$	$V_p = \frac{\pi}{4} D^2 h = \frac{\pi}{4}(0.1)^2(1) = 0.00785\ mm^3$ $d_v = \sqrt[3]{\frac{6V_p}{\pi}} = \boxed{0.247\ mm}$ $SA_s = \pi D^2 = \boxed{0.192\ mm^2}$ $SA_p = \pi D\left(\frac{D}{2} + h\right) = \boxed{0.329\ mm^2}$ $\varphi = \frac{0.192}{0.329} = \boxed{0.584}$ ~~sieve~~ diameter → $\pi D^2 = 0.314\ mm^2$ ✗ Projected area ↳ $\boxed{D_H = 0.1\ mm}$ smaller sieve diameter = $\boxed{0.1\ mm}$

14

Q2. It is desired to crush 9080 kg/h of iron ore hematite. The size of the feed is such that 80% passes a 76.2 mm screen and 80% of the product is to pass a 3.175 mm screen. The work index is 0.0503 $kWm^{0.5}/(kg/s)$.

1. Calculate the power required in kW
2. Calculate the power required (in kW) to crush the product further where 80% is less than 1000 μm.

Q3. A finely divided sample of water and insoluble organic pigment of density 1425 kg/m^3 was thoroughly dispersed in water and the suspension transferred to a centrifuge tube. The surface of the liquid in the tube was 16.5 cm from the axis of rotation of the centrifuge.
After centrifuging for 360 s at 360 revolutions per minute a pipette was lowered into the centrifuge tube and a small sample of the suspension withdrawn from 1.0 cm below the surface.
Determine the particle size of the organic pigment which was suspended in this sample.
Density of water = 998 kg/m^3, Viscosity of water = 1.24 mN s/m^2

$$Q = \frac{250\ cm^3}{12\ min \times \frac{60\ s}{1\ min} + 54\ s} = 0.32\ cm^3/s \times \frac{1\ m^3}{(100\ cm)^3}$$

$$= 0.32 \times 10^{-6}\ m^3/s$$

$$e = 1 - \frac{\text{vol. of solids}}{\text{total vol.}}$$

$$\text{vol. of solids} = \frac{25.4 \times 10^{-3}\ kg}{3100\ kg/m^3} = 8.19 \times 10^{-6}\ m^3 \qquad V = \frac{m}{\rho}$$

$$\text{vol of Cell (total vol)} = \frac{\pi}{4}(2.5 \times 10^{-2})^2 (2.73 \times 10^{-2}) = 1.34 \times 10^{-5}\ m^3$$

$$V_{Tot} = \frac{\pi}{4} d^2 L$$

$$e = 1 - \frac{8.19 \times 10^{-6}}{1.34 \times 10^{-5}} = 0.39$$

$$\Delta P = \rho_{Hg}\, g h$$

$$= \frac{13600\ kg}{m^3} \times 9.8\ \frac{m}{s^2} \times -12.5\ cm \times \frac{1\ m}{100\ cm}$$

$$= -16660\ \frac{kg}{m.s^2} \times \frac{1\ N}{1\ \frac{kg.m}{s^2}} = -16660\ N/m^2\ (Pa)$$

$$u = \frac{3.2 \times 10^{-7}}{\frac{\pi}{4}(2.5 \times 10^{-2})^2} = 8.42 \times 10^{-4}\ m/s \qquad u = \frac{Q}{A}$$

$$u = \frac{1}{180} \frac{e^3 d^2}{(1-e)^2 \mu} \frac{(-\Delta P)}{L}$$

$$8.42 \times 10^{-4} = \frac{1}{180} \frac{(0.39)^3 d^2}{(0.61)^2 \times 1.82} \times \frac{16660}{2.73 \times 10^{-2}}$$

$$d^2 = 2.8 \times 10^{-12}$$

$$d = 1.68 \times 10^{-6}\ m = 1.68\ \mu m$$

1 (a) Determin $d_v = \Sigma x_i d_i$, Σ weight = 100

average size	x_i	$x_i d_i$	$1/(x_i/d_i^3)$
0.099	0.053	5.247×10^{-3}	54.62
0.05	0.078	3.9×10^{-3}	624
0.027	0.175	4.275×10^{-3}	8891
0.015	0.295	$K \times 4.425 \times 10^{-3}$	87407
0.008	0.221	1.768×10^{-3}	131640.475
0.005	0.126	6.3×10^{-4}	1008000
0.003	0.042	1.26×10^{-4}	1555555
0.001	0.01	1×10^{-5}	10^7
			13092112.75

$K \times 1.2$

$d_v = \Sigma x_i d_i = k \times 0.02$ mm

$= 1.2 \times 0.02 = 0.024$

(b) mean $d_{v'} = \sqrt[3]{\dfrac{1}{\Sigma(x_i/d_i^3)}} = \sqrt[3]{\dfrac{1}{\Sigma \dfrac{x_i}{k^3 d_i^3}}} = \sqrt[3]{\dfrac{1}{k^3 \Sigma \dfrac{x_i}{d_i^3}}}$

$= \sqrt[3]{\dfrac{1}{k^3}} \times \sqrt[3]{7.64 \times 10^8} = \sqrt[3]{\dfrac{1}{(1.2)^3}} \times 4.24 \times 10^{-3} = 3.53 \times 10^{-3}$

(c)

size	accumulated Frequency	
0.099	5.3	0.053
0.05	5.3 + 7.8 = 13.1	0.131
0.027	13.1 + 17.5 = 30.6	0.306
0.015	60.1	0.601
0.008	82.2	0.822
0.005	94.8	0.948
0.003	99	0.99
0.001	100	1

22 a $d_A = 0.4\ mm$, $d_B = 0.9\ mm$.

21 what is the Ratio of U_{oA} / U_{oB}.

- stoke $F = 3\pi\mu u_o d$ $F_G = \frac{\pi}{6} d^3 (\rho_s - \rho) g$

$F = F_G$

$3\pi\mu u_o d = \frac{\pi}{6} d^3 (\rho_A - \rho) g$

$U_{oA} = \frac{d_A^2 \cdot g (\rho_A - \rho_w)}{18\mu}$

$\rho_A = \rho_B$

$U_{oB} = d_B^2 \frac{g (\rho_B - \rho_w)}{18\mu}$

$\frac{U_{oA}}{U_{oB}} = \frac{d_A^2 \times \cancel{\theta}}{d_B^2 \times \cancel{\theta}} \Rightarrow \frac{U_{oA}}{U_{oB}} = \left(\frac{0.4\ mm}{0.9\ mm}\right)^2 = 0.198$

- Newtons Region

$\frac{R'}{\rho u^2} = 0.05$, $F = R' * Area = 0.05 \times \rho_w U_o^2 \times \frac{\pi}{4} d^2$

$F_G = \frac{\pi}{6} d^3 (\rho_s - \rho) g$

$U_{oA}^2 * 0.05 * \rho_w * \frac{\pi}{4} d_A^2 = \frac{\pi}{6} d_A^3 (\rho_A - \rho) g$

$U_{oA}^2 = \frac{4 d_A (\rho_A - \rho) g}{6 * 0.05 * \rho_w}$

$U_{oB}^2 = \frac{4 d_B (\rho_B - \rho) g}{6 * 0.05 * \rho_w}$

$\frac{U_{oA}^2}{U_{oB}^2} = \frac{d_A * \cancel{\theta}}{d_B * \cancel{\theta}} \Rightarrow \left(\frac{U_{oA}}{U_{oB}}\right)^2 = \frac{d_A}{d_B}$

$\frac{U_{oA}}{U_{oB}} = \sqrt{\frac{0.4}{0.9}} = \frac{2}{3}$

(b) Both

• in Stok Region $\frac{U_{oA}}{U_{oB}} = 0.198$

$\Rightarrow U_{oB} = 1\ m/s \Rightarrow U_{oA} = 0.198$

$$U_{oA} = \frac{d_A^2\, g(\rho_A - \rho)}{18\mu} = \frac{(0.4\times10^{-3})^2 * 9.81 * (2750 - 1000)}{18 * 0.001}$$

$= 0.1526$

$$U_{oB} = \frac{d_B^2\, g(\rho_B - \rho)}{18\,\mu} = \frac{(0.9\times10^{-3})^2 * 9.81 * (2750 - 1000)}{18 * 0.001} = 0.7725$$

100% Removal

So $U_{oB} = 0.7725$

$\frac{U_{oA}}{U_{oB}} = 0.198 * 0.7725 = 0.1526$ $\Rightarrow$ also $U_{oA} = 100\%$

• For Newton Region $\frac{U_{oA}}{U_{oB}} = \frac{2}{3}$

$$U_{oB}^2 = \frac{4 d_B\, (\rho_B - \rho) g}{6 * 0.05 * \rho} = \frac{4 * 0.9\times10^{-3} * (2750 - 1000) * 9.81}{6 * 0.05 * 10^3}$$

$= 0.20601 \Rightarrow U_{oB} = 0.454\ m/s$

100% Removal

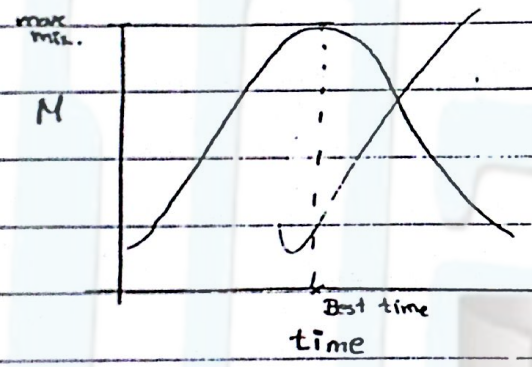
$$U_{oA}^2 = \frac{4 * 0.4\times10^{-3} * 1750 * 9.81}{6 * 0.05 * 10^3} \Rightarrow U_{oA} = 0.302$$

100% Removal

(c) $\psi = \frac{6 * \frac{\pi}{6} D^3}{D_p * \pi D^2} = \frac{D}{D_p}$ = ~~volume of circle as~~

$\psi = \frac{6 * \frac{\pi}{6} D^3}{}$

(3) (a) Draw the of M with time



(b) List nature of material to Be crushed.

1- hardness :- with hard material use low speed crusher and the hardness is determined By mohr scale.

2- ~~streng~~ crushing strength : as it increase power is increase for ~~cr~~ crushing.

3- stickness :- when the material stick we should use machine which can be cleaned easily

4- soapness

5- Friability : tendency of material to fracture.

6- Explosion :- material which are explosive should be crushed with an inert of atmosphere.

7- ~~diameter of the particle~~ Moisture content

8- structure

University of Jordan
Department of Chemical Engineering
95442 Unit Operation of Particulate Solids

Homework No.1

1. The following table gives the size distribution of a dust as measured by the microscope. Convert these figures to obtain the distribution on a weight basis, and calculate surface mean diameter and the specific surface, assuming spherical particles of specific gravity 2.65.

Size range in um	Number of particles in range
0-2	2000
2-4	600
4-8	140
8-12	40
12-16	15
16-20	5
20-24	2

$\frac{\mu m^2}{\mu m^3}$ = sp. surface

Q2. A crusher in reducing limestone of crushing strength 70 MN/m^2 from 6 mm diameter average size to 0.1 mm diameter average size requires 9 kW. The same machine is used to crush dolomite at the same rate of output from 6 mm diameter average size to a product which consists of 20% with an average diameter of 0.25 mm, 60% with an average diameter of 0.125 mm, the balance having an average diameter of 0.085 mm. Estimate the power required to drive the crusher, assuming that the crushing strength of the dolomite is 100 MN/m^2 and that crushing follows Ritinger's law.

Use the weight mean diameter in you calculation

Use % as numbers not x

University of Jordan

Department of Chemical Engineering

95442 Unit Operation of Particulate Solids

Homework No. 1

1. The following table gives the size distribution of a dust as measured by the microscope. Convert these figures to obtain the distribution on a weight basis, and calculate surface mean diameter and the specific surface, assuming spherical particles of specific gravity 2.65.

Size range in um	Number of particles in range
0-2	2000
2-4	600
4-8	140
8-12	40
12-16	15
16-20	5
20-24	2

Q2. A crusher in reducing limestone of crushing strength 70 MN/m^2 from 6 mm diameter average size to 0.1 mm diameter average size requires 9 kW. The same machine is used to crush dolomite at the same rate of output from 6 mm diameter average size to a product which consists of 20% with an average diameter of 0.25 mm, 60% with an average diameter of 0.125 mm, the balance having an average diameter of 0.085 mm. Estimate the power required to drive the crusher, assuming that the crushing strength of the dolomite is 100 MN/m^2 and that crushing follows Ritinger's law.

Use the weight mean diameter in your calculation

Hw 2

Q1 :- $D = 2\,mm$ $\rho_s = 7870\ kg/m^3$

$\rho_p = 900\ kg/m^3$ $\mu = 50\ mNs/m^2$

$$\rightarrow \frac{R_o'}{\rho u_o^2} Re'^2 = \frac{2}{3}\frac{d^3}{\mu^2}\rho(\rho_s-\rho)g$$

$$= \frac{2}{3}\frac{0.002^3}{0.05^2}\,900(7870-900)\,9.81$$

$$= 131.3$$

$$\log 131.3 = 7.118$$

From table 3.4 $\rightarrow$ $\log Re_o' = 0.833$

$$Re_o' = 6.8$$

$$u_o = 6.8 \times 0.05 / 900 \times 0.002 = \boxed{0.189\ m/s}$$

Q2 :-

$$y = \frac{b}{a}t - \frac{b}{a^2}(1-e^{-at})$$

$$b = g\left(1-\frac{\rho}{\rho_s}\right) = 9.81\left[1-\left(\frac{1000}{2650}\right)\right] = 6.108\ m/s^2$$

$$a = \frac{18\mu}{d^2\rho_s} = \frac{18 \times 1.2\times10^{-3}}{(20\times10^{-6})^2 \times 2650} = 203775^{-1}$$

$y = 180\ mm$ or $0.18\,m$

$$\rightarrow 0.18 = \frac{6.108}{203775}t - \frac{6.108}{(203775)^2}(1-\exp(-203775t))$$

$\hookrightarrow$ neglected

$$t = \frac{0.18}{0.0003} = \boxed{600\,s}$$

University of Jordan
Department of Chemical Engineering
Unit Operation of Particulate Solids
H.W. No. 3

Q1. In a contact sulphuric acid plant the secondary converter is a tray type converter, 2.3 m in diameter with the catalyst arranged in three layers, each 0.45 m thick. The catalyst in is the form of cylindrical pellets 9.5 mm in diameter and 9.5 mm long. The void fraction is 0.35. The gas enters the converter at 675 K and leaves at 720 K. Its inlet composition is

SO_3 6.6, SO_2 1.7, O_2 10.0, N_2 81.7 mol%

and its exit composition

SO_3 8.2, SO_2 0.2, O_2 9.3, N_2 82.3 mol%

The gas flow rate is 0.68 kg/m^2s. Calculate the pressure drop through the converter by using carman method.

$\mu = 0.032$ m Ns/m^2

Q2. A column 0.6 m diameter and 4 m tall, packed with 25 mm ceramic hollow packings is used in a gas absorption process carried out at atmospheric pressure and 293 K. If the liquid and gas can be considered to have the properties of water and air, and their flow rates are 6.5 and 0.6 kg/m^2 s respectively, what will be the pressure drop across the column ?

Use Carman's method,

Data: Specific Surface of packing $S = 656\ m^2/m^3$
mean voidage of bed $e = 0.71$
Viscosity of vapor $\mu = 0.018$ m Ns/m^2
Kilogram molecular volume $= 22.4\ m^3/kmol$.

/SA.