MANICALAND STATE UNIVERSITY OF APPLIED SCIENCES

FACULTY OF ENGINEERING

DEPARTMENT: CHEMICAL AND PROCESSING ENGINEERING

MODULE: FLUID SOLID SYSTEMS/PARTICULATE TECHNOLOGY

CODE: CHEP 313/HCHE 325

SESSIONAL EXAMINATIONS
NOVEMBER 2022

DURATION: 3 HOURS

EXAMINER: C. MUHEZWA

INSTRUCTIONS

1. *Answer **All** questions.*
2. *Start a new question on a fresh page*
3. *Total marks 100*

Additional material(s): *Graph paper, Calculator*

QUESTION 1

a. Outline the **three** most important characteristics of an individual particle. [3]

b. Explain the meaning of the following terms as they are used in particle technology:

   i. *Surface diameter,*

   ii. *Surface-to-volume diameter,*

   iii. *Martin's diameter,*

   iv. *Free falling diameter.* [4]

c. A solid sample from an industrial plant has cubic particles with average edge length of 4.4 μm. Determine the

   i. volume-equivalent sphere diameter (D_{volume}) [3]

   ii. surface-equivalent sphere diameter ($D_{surface}$) [3]

   iii. volume-surface equivalent sphere diameter (*Dsv*) of the partcles [2]

d. Derive from first principles, the terminal falling velocity of a particle of density ρ_p in a fluid of density ρ_f and viscosity μ. Assume the particle's motion is under gravity and is in the Stoke's region. [10]

QUESTION 2

a. What is meant by

   i. *dense phase pneumatic conveying* [3]

   ii. *saltation velocity* [2]

   iii. *choking velocity* [2]

b. State **four** examples of particulate solids that can be transported by pneumatic conveying. [4]

c. The general relationship between gas velocity and pressure gradient $\Delta P/\Delta L$ for a horizontal transport line is shown in **Fig 1**. Line AB represents the

curve obtained for gas only in the line, CDEF for a solids flux, G_1, and curve GH for a higher solids feed rate, G_2.

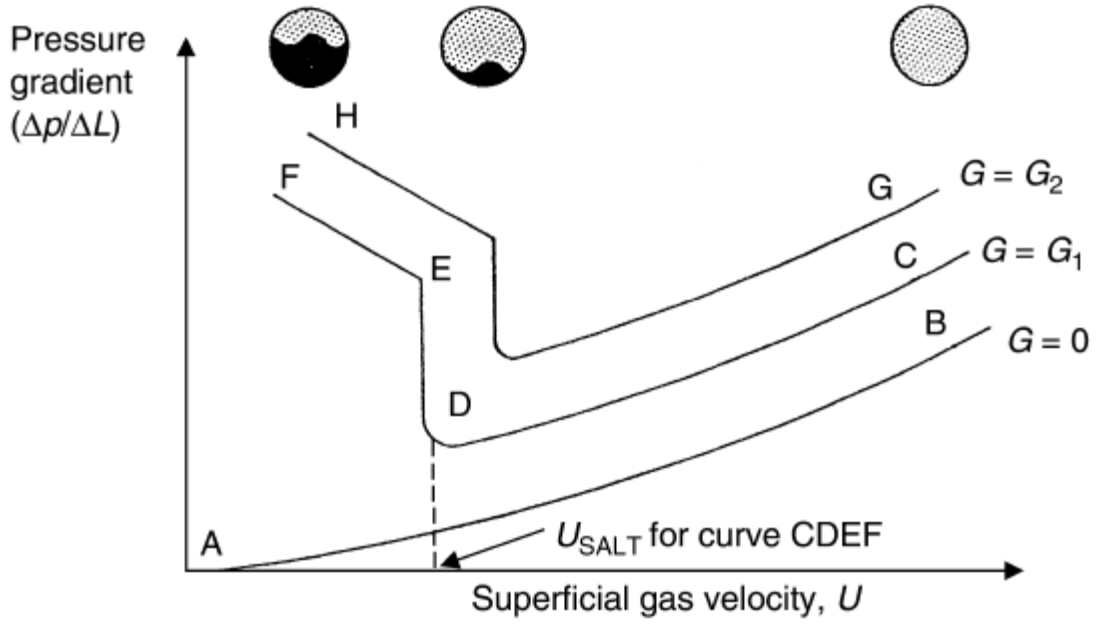

Fig. 1: Phase diagram for dilute phase horizontal pneumatic transport

i. Describe and explain what happens if the gas velocity is reduced whilst solids feed rate is kept constant at *G1* [8]

ii. Explain the shape of the graph when $G = 0$ [3]

d. What are the advantages of pneumatic conveying over mechanical conveying in particulate technology? [3]

QUESTION 3

a. Describe the principle behind the *elutriation* method of particle size measurement. [4]

b. What are the assumptions made in the sedimentation method of particle size measurement? [3]

c. Crystalline fertiliser solid particles are immersed in a liquid solvent of viscosity 10 Pa s, and density 60 kg/dm^3. The density of the solid particles is 53 kg/m^3 and their final settling velocity 5.3 m/s.

   i. What is meant by the *'final settling velocity'* [2]

   ii. Determine the equivalent Stokes diameter (D_s) of the fertiliser particles? Assume Stoke's law apply. [4]

d. Explain the need for particle size reduction in particulate technology [2]

e. State Rittinger's law of the energy needed for particle size reduction [2]

f. A material is crushed in a Blake jaw crusher such that the average size of particle is reduced from 40 mm to 10 mm with the consumption of energy of 13.0 kW/(kg/s). What would be the consumption of energy needed to crush the same material of average size 85 mm to an average size of 15 mm:

   i. assuming Rittinger's law applies? [3]

   ii. assuming Kick's law applies? [3]

g. What are the factors that affect the choice of machine selected for a particular grinding operation? [2]

QUESTION 4

a. Explain what is meant by *in situ* sampling [2]

b. What are the advantages of *in situ* sampling? [3]

c. Describe the principle behind the *coning and quartering* method of sampling [4]

d. Table 4.1 shows results of a grain size sieve analysis done on brown clayey to silty sand, trace fine gravel.

Table 4.1: Grain size sieve analysis

Sieve Number	Diameter (mm)	Mass of Empty Sieve (g)	Mass of Sieve+Soil Retained (g)	Soil Retained (g)	Percent Retained	Percent Passing
4	4.75	116.23	166.13	49.9	9.5	90.5
10	2.0	99.27	135.77	36.5	7.0	83.5
20	0.84	97.58	139.68	42.1	8.0	75.5
40	0.425	98.96	138.96	40.0	7.6	67.8
60	0.25	91.46	114.46	23.0	4.4	63.4
140	0.106	93.15	184.15	91.0	17.4	46.1
200	0.075	90.92	101.12	10.2	1.9	44.1
Pan	---	70.19	301.19	231.0	44.1	0.0
			Total Weight=	523.7		

i. Construct a cumulative plot showing particle size distribution curve. [8]

ii. Determine D_{10}; D_{50} and D_{90} [3]

iii. Hence determine the span of the distribution [3]

iv. How are the particles from the bottom pan characterized? [1]

v. Describe any source of error in the sieving experiment [1]

END OF EXAMINATION