Prince of Songkla University

Faculty of Engineering

Midterm Examination: Semester 2 **Academic Year: 2010**

Date: December 18, 2010 **Time: 9:00-12:00 am**

Subject: 226-403 Particulated Material Technology **Room: A401**

ทุจริตในการสอบ โทษขั้นต่ำปรับตกในรายวิชานั้นและพักการเรียน 1 ภาคการศึกษา

Name... Surname ....Student ID..............................

Instruction:

1. ***There are 2 parts, 20 questions, 11 pages; 120 points***
2. ***Attempt all questions.***
3. ***Only a hand-written note on two-sided A4 and a dictionary are allowed.***
4. ***Borrowing things form other students is prohibited.***

Napisporn Memongkol

Instructor

Some important equations

$D_A = (4\,A / \pi)^{1/2}$ $D_V = (6\,V / \pi)^{1/3}$ $D_S = (S / \pi)^{1/2}$

A = projected area, V = volume, S = surface area, D_A = equivalent spherical projected diameter, D_V = equivalent spherical volume diameter, D_S = equivalent spherical surface diameter

$$\sigma = \sqrt{\frac{2Er}{D}} \qquad t = C\,d^2 / N^{1/2}$$

σ = impact stress require to fracture a brittle material, E = elastic modulus,
r = defect or existing crack tip radius, D = particle size, t = grinding time,
C = empirical constant depends on the process and desired level,
d = the grinding media, N = rotational speed

$$V = H/t = g\,D^2\,(\rho_m - \rho_f) / (18\,\eta)$$

V = terminal velocity, H = settling height, t = settling time, D = particle size,
g = acceleration (gravitational constant, 9.8 m/s^2) ρ_m = particle density,
ρ_f = density of the fluid, η = fluid viscosity

$$K = P_{H_2O} / P_{H_2} \qquad J = A \exp(-Q/RT)$$

K = the equilibrium constant, P_{H2} = the partial pressure of hydrogen,
P_{H2O} = the partial pressure of water, J = reaction rate, A = material constant,
R = gas constant, T = absolute temperature

$$D = \left(\frac{A}{\omega}\right)\sqrt{\frac{\gamma}{\rho_m R}} \qquad C_R = V_L/V_C = \rho_G/\rho_A$$

A = a process dependent constant, ω = angular velocity, γ = surface energy of the melt, ρ_m = density of the melt, R = radius of the electrode

PART I: Fill in the blank using the letter (a - jj) provided in the next page that is related to the questions (2 point each) 30 points

1. "a finely divided solid, smaller than 1 mm in its maximum dimension" is a definition of ....
2. The three main reasons for using powder metallurgy are a) ...., b) ...., and c) ....
3. One of the best tools available for observing the discrete characteristics of metal powders is ....
4. For a cubic particle with a size of 1 μm as measured on each edge, determine the equivalent spherical diameters.

   4.1) The equivalent spherical projected diameter D_A = ...

   4.2) The equivalent spherical volume diameter D_V = ...

   4.3) The equivalent spherical surface diameter D_S = ...
5. The buoyancy force or (F_B) is determined by ....
6. The equation "D = 0.9 λ / B cos (θ)" using in X-ray technique that applied to size analysis of very small particles. What is "B"? ....
7. The weight distribution is skewed to the .... particle sizes in comparison to the population based distribution.
8. The two most important factors in gas atomization that affect the particle size are .... and ....
9. The two outstanding differences between gas atomization and water atomization are .... and ....

Answers for PART I

a) shaping	b) 1.18 μm	c) economic
d) energy saving	e) smaller	f) 1.27 μm
g) particle size	h) TEM	i) 1.24 μm
j) gas type	k) apparent density	l) coarser
m) dispersant	n) melt superheat	o) fluid velocity
p) captive	q) $g \rho_m \pi D^3 / 6$	r) $3\pi D V \eta$
s) 1.48 μm	t) diffraction angle	u) powder

v) maximum intensity	w) SEM	x) intensity
y) surface contamination	z) $g \rho_f \pi D^3 / 6$	aa) atmosphere
bb) nozzle geometry	cc) 1.38 μm	dd) light microscope
ee) 1.13 μm	ff) peak broadening	gg) powder shape
hh) gas velocity on exit	ii) unique	jj) compaction

PART II: Answer all the questions

1. (4 points) The applications for PM components fall into two main groups. The first group is ....

   ....

   and the second group is ....

   ....

2. (6 points) The PM industry divided into three groups, what are they?

   a) ....

   ....

   b) ....

   ....

   c) ....

   ....

3. (4 points) Comparison between **<u>shaping</u>** and **<u>compaction</u>**?

   ....

   ....

   ....

   ....

   ....

4. (6 points) Give the meaning of these densities;

   Pycnometer density ....

   green density ....

   apparent density ....

5. (4 points) What is the meaning of debinding? Give two options of debinding in the PM processes?

....

....

....

....

6. (10 points) Three lots of bronze powders (representing **water atomized, gas atomized, and hydrogen reduced powders**) are tested with the following results (theoretical density of bronze = 8.8 g/cm^3):

properties	Lot A	Lot B	Lot C
mean size, mm	48	25	40
apparent density, g/cm^3	2.8	1.7	4.4
tap density, g/cm^3	3.3	2.4	4.7
flow rate, s for 50 g	32	50	21
surface area, m^2/g	0.014	0.063	0.017

Identify which lot represents each of the powder fabrication techniques and justify your answer. (ผงแต่ละล็อต เป็นผงชนิดใด พร้อมเหตุผลสนับสนุน)

Supap

7. (8 points) A spherical nickel powder is analyzed for particle size using sedimentation. The powder is dispersed in water at the top of a settling column 100 mm high. If the particle size is 8 μm, then what is the expected settling time?
(Ni density = 8.9 g/cm^3, water density = 1 g/cm^3, water viscosity = 10^{-3} kg/m.s)
(เวลาที่ใช้ในการตกตะกอน)

8. (8 points) Iron powder is screened into -100/+200 mesh and -325 mesh fractions. The apparent density of the coarse fraction is 2.6 g/cm^3 and the fine fraction has an apparent density of 2.3 g/cm^3. When a blend is prepared using 20% fine particles in the coarse fraction, the apparent density is measured as 2.8 g/cm^3. Explain the effect. (อธิบายผลที่เกิดขึ้นว่าทำไมเป็นเช่นนั้น)

9. (10 points) The green density for a stainless steel powder is to be 6.5 g/cm^3. The apparent density is 2.7 g/cm^3; what is the compression ratio (C_R) and what is the required powder fill for a final compact height of 4 cm? (ความสูงตอนแรกเท่าไหร่)

10. (10 points) A 1 mm particle requires approximately 4 s to solidify in a low pressure gas atomizer and travels 10 m during this solidification time. What would be the travel distance before solidification for a 100 μm particle produced under the same atomization conditions?

11. (20 points) Data are collected by screening for a copper powder (theoretical density of copper = 8.9 g/cm^3) as follow:

mesh size	Weight, g
-325	0
+325/-270	3
+270/-230	16
+230/-200	43
+200/-170	56
+170/-140	35
+140/-120	29
+120/-100	15
+100/-80	4
+80	0

a) (10 points) Complete the table (calculate for particle size, weight percent, population, population percent, cumulative weight percent finer, and cumulative population percent finer)

b) (6 points) Plot the graphs of particle size distribution on page 11 (last page of this exam) showing the cumulative percent finer (both **weight** and **population**) versus the $\log_{10}$ of the particle size.

c) (2 points) What is the mean particle size on a weight basis?

d) (2 points) Estimate the mean particle size on a population basis.

Table (Standard sieve sizes)

mesh size	Opening, μm	mesh size	Opening, μm
35	500	140	106
40	425	170	90
45	355	200	75
50	300	230	63
60	250	270	53
70	212	325	45
80	180	400	38
100	150	450	32
120	125	500	25

สูตรที่กำหนดให้ $$n = \frac{6W}{\rho_m \pi D^3}$$

Table for particle size distribution data

size (μm)	Weight (g)	% wt	weight cumulative % finer	population	% pop	Population Cumulative % finer
	0					
	3					
	16	**1=**	**2=**	**3=**	**4=**	**5=**
	43					
	56					
	35					
	29					
	15					
	4					
	0					

***Show your calculation on the next page**

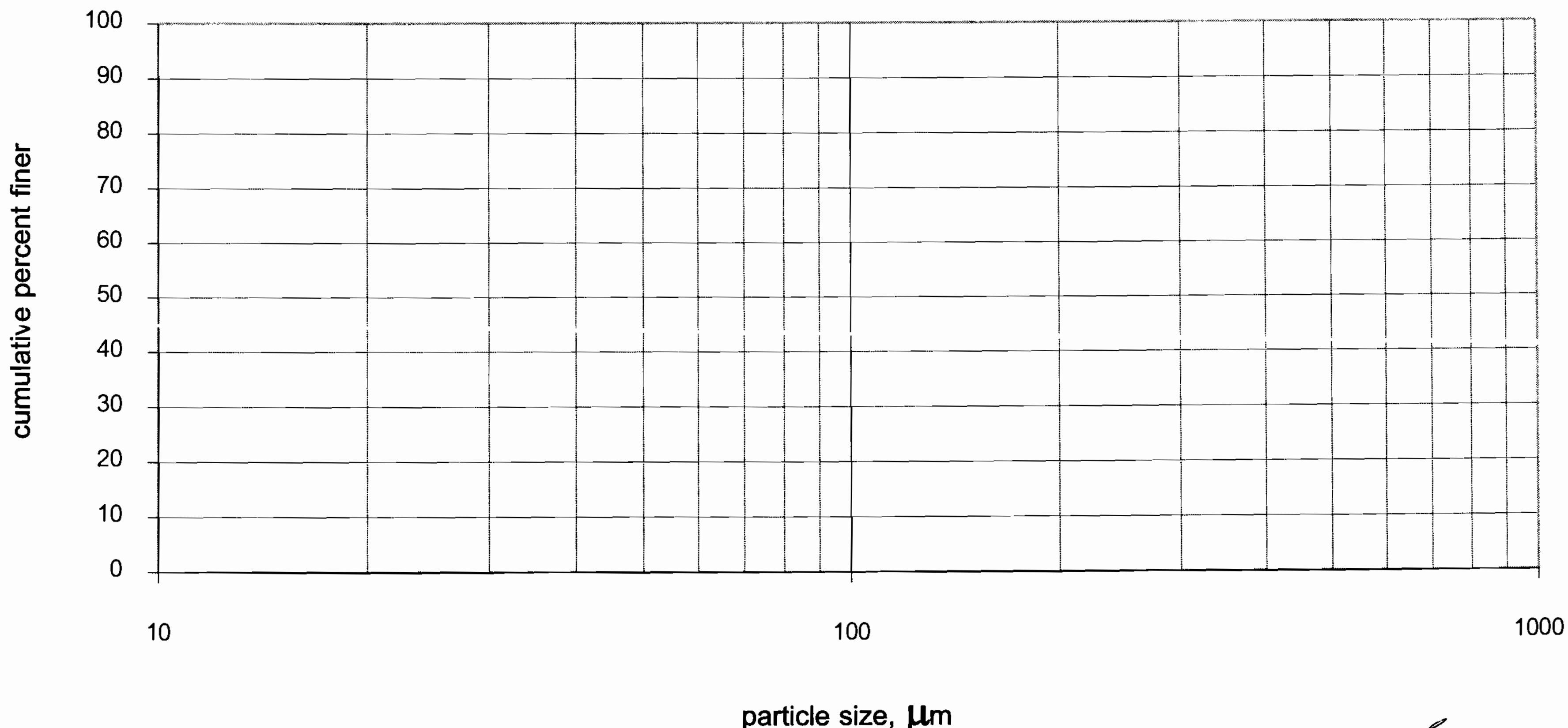
<u>หมายเหตุ</u> ให้แสดงวิธีการคำนวณเฉพาะค่าที่อยู่ในช่องหมายเลข **1, 2, 3, 4 และ 5** ส่วนค่าอื่นๆ ไม่ต้องแสดงการคำนวณให้นำค่าที่คำนวณได้มาใส่ได้เลย

<u>From your plot, Answer these questions</u>

c) The mean particle size of Cu on a weight basis =.................. μm

d) The mean particle size of Cu on a population basis = ... μm

Cumulative particle size distribution



Show your calculation here

No. 1

No. 2

No. 3

No. 4

No. 5