
UNIVERSITI SAINS MALAYSIA

Second Semester Examination
Academic Session 2007/2008

April 2008

EBS 215/3 - Comminution and Sizing **[Kominusi dan Pensaizan]**

Duration : 3 hours
[Masa : 3 jam]

Please ensure that this examination paper contains ELEVEN printed pages before you begin the examination.

[Sila pastikan bahawa kertas peperiksaan ini mengandungi SEBELAS muka surat yang bercetak sebelum anda memulakan peperiksaan ini.]

This paper contains SEVEN questions.

[Kertas soalan ini mengandungi TUJUH soalan.]

Instructions: Answer FIVE questions. If a candidate answers more than five questions only the first five questions in the answer sheet will be graded.

[Arahan: Jawab LIMA soalan. Jika calon menjawab lebih daripada lima soalan hanya lima soalan pertama mengikut susunan dalam skrip jawapan akan diberi markah.]

Answer to any question must start on a new page.

[Mulakan jawapan anda untuk setiap soalan pada muka surat yang baru.]

You may answer a question either in Bahasa Malaysia or in English.

[Anda dibenarkan menjawab soalan sama ada dalam Bahasa Malaysia atau Bahasa Inggeris.]

1. [a] The energy consumed in comminution is one of the main costs in mineral processing and it is important to have some appreciation of the energy consumed-size reduction achieved relationship when designing plants. Write the general differential equation which describes the energy-particle size relationship. Define the theories of Kick, Rittinger and Bond and show on the graph the regions in which they might be expected to apply. Why do you think that none of these theories have been found to be applicable over a wide range?

Tenaga yang digunakan dalam kominusi merupakan salah satu kos utama dalam pemrosesan mineral dan adalah penting untuk mengambilkira perhubungan tenaga yang digunakan - pengurangan saiz yang diperolehi, apabila merekabentuk sesebuah loji. Tuliskan persamaan pembezaan umum yang memperihalkan hubungan di antara tenaga dengan saiz partikel. Jelaskan teori Kick, Rittinger and Bond, serta tunjukkan dalam graf zon di mana teori-teori ini boleh diaplikasikan. Mengapakah didapati semua teori di atas tidak dapat di aplikasikan dalam julat yang lebih besar?

(50 marks/markah)

- [b] A sample of quartz taken from the output of a ball mill operating in open circuit has the following size distribution:

Sampel kuarza yang diambil daripada hasil produk pengisar bebola yang beroperasi dalam litar terbuka mempunyai taburan saiz seperti berikut:

Size range (μm) <i>Julat saiz (μm)</i>	Weight (%) <i>Berat (%)</i>
+4000	2
4000 - 2000	20
2000 - 1000	24
1000 - 500	21
500 - 250	14
250 - 125	9
-125	10

The material is ground in a laboratory mill for 30 minutes, and at the end of this period the 80% passing size of the product is 350 μm . If the grinding in the laboratory mill is prolonged for a further 15 minutes, determine the size through which 80% of the product should pass (assuming that Bond's "Law" applies) and give a fractional size analysis of the product, stating any assumptions which are made. (Graph paper provided).

Suatu bahan dikisar di dalam pengisar berskala makmal selama 30 minit, dan pada akhir masa tersebut, didapati 80% saiz produk melepasi 350 μm . Jika masa pengisaran bagi pengisar tersebut ditambah selama 15 minit lagi, tentukan saiz di mana 80% daripada produk melepasi saiz tersebut (dengan menganggap Hukum Bond digunakan) dan berikan analisis pecahan saiz produk, dengan menyatakan sebarang andaian yang dibuat. (Kertas graf disediakan).

(50 marks/markah)

2. [a] Draw the cross section of a single toggle jaw crusher and a standard cone crusher. Then describe how the cone crusher is able to crush fine, while a jaw crusher may not.

Lakarkan keratan rentas penghancur rahang togal tunggal (single toggle jaw crusher) dan penghancur kon standard. Huraikan sejauh manakah penghancur kon mampu menghancurkan sehingga halus, manakala tidak bagi penghancur rahang.

(35 marks/markah)

- [b] What is the meaning of size reduction ratio? Give an example.

Apakah maksud nisbah pengurangan saiz? Berikan contoh.

(15 marks/markah)

- [c] A hard ore of nominal top size of 600 mm is to be crushed at a rate of 350 tons per hour. A 10 mm product is required as the feed to the grinding mills. Suggest a flowsheet of the crushing plant, including sizing operations where required, to handle this ore. Indicate the machine types and product sizes at each stage. You can assume that the ore has a work index of 20 and will be delivered by surface haulage in dump trucks.

Suatu bijih keras yang saiz namaan atas 600 mm perlu dihancurkan pada kadar 350 ton sejam. Produk 10 mm diperlukan sebagai suapan untuk pengisaran. Cadangkan carta alir bagi loji penghancuran, termasuk operasi pensaizan dimana diperlukan, untuk mengendalikan bijih tersebut. Nyatakan jenis mesin dan saiz produk pada setiap peringkat. Anda boleh menganggap bahawa indeks kerja bijih tersebut adalah 20 dan dihantar secara pengangkutan permukaan dalam trak longgokan.

(50 marks/markah)

3. [a] Discuss the mechanisms of breakage involved in ball mills, rod mills, autogenous mills and semi-autogenous (SAG) mills.

Bincangkan mekanisma pemecahan yang terlibat dalam pengisar bebola, pengisar rod, pengisar autogenous dan pengisar semi-autogenous (SAG).

(40 marks/markah)

- [b] Describe the effect of ball size on the breakage rate in ball mills and SAG mills.

Huraikan kesan saiz bebola ke atas kadar pemecahan dalam pengisar bebola dan pengisar SAG.

(20 marks/markah)

- [c] Table Q2 shows the results of two grinding mills of a grinding plant in Pahang.

Jadual S2 menunjukkan keputusan dua pengisar bagi loji pengisaran di Pahang.

Table Q2
Jadual S2

Quantity <i>Kuantiti</i>	Feed (mm) <i>Suapan (mm)</i>	Product (mm) <i>Produk (mm)</i>	W (KWj/ton) <i>W (KWj/ton)</i>	W_i (test) <i>W_i (ujian)</i>
Ball mill <i>Pengisar Bebola</i>	23	0.6	4.81	13.08
Tube mill <i>Pengisar Tiub</i>	1.58	0.23	5.84	13.08

Using Bond Work Index formula, determine the plant's Bond Work Index (W_i -plant) and the relative mechanical efficiency for both mills. Comment on the results.

Dengan menggunakan formula Indeks Kerja Bond (Bond Work Index), tentukan Indeks Kerja Bond loji (W_i - loji) dan kecekapan relatif mekanikal untuk kedua-dua pengisar. Komen keputusan yang diperolehi.

(40 marks/markah)

4. [a] What are the advantages and disadvantages of a hydrocyclone classifier over mechanical types of classifiers?

Apakah kebaikan dan keburukan pengkelas hidrosiklon berbanding dengan jenis pengkelas mekanikal?

(40 marks/markah)

- [b] As a process engineer you are required to operate the grinding circuit as shown in Figure Q4.

Sebagai jurutera proses, anda dikehendaki untuk mengoperasikan litar pengisaran seperti yang ditunjukkan dalam Rajah S4

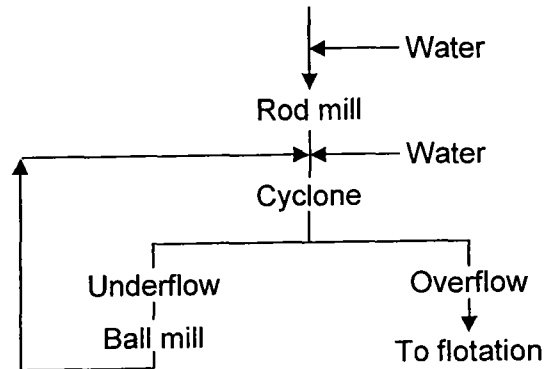


Figure Q4

Rajah S4

The rod mill is fed at the rate 55 t/h of dry solids (density 2900 kg/m³). The percent solids analyses of the rod mill discharge, cyclone feed, cyclone overflow and cyclone underflow gave the following results:

Pengisar rod disuap pada kadar 55 t/j pepejal kering (ketumpatan 2900 kg/m³). Analisis peratus pepejal bagi produk pengisar rod, suapan siklon, aliran atas siklon dan aliran bawah siklon memberikan keputusan berikut:

Rod mill discharge = 62% solids
 Cyclone feed = 48% solids
 Cyclone overflow = 31% solids
 Cyclone underflow = 74% solids

Produk pengisar bebola = 62% pepejal
Suapan siklon = 48% pepejal
Aliran atas siklon = 31% pepejal
Aliran bawah siklon = 74% pepejal

For optimum performance, the water requirement which produces optimum slurry composition in all parts of the circuit is required. Calculate the circulating load in the grinding circuit shown in Figure Q4 and then determine the amounts of water that need to be added to the rod mill and cyclone feed.

Untuk prestasi optimum, keperluan air yang menghasilkan komposisi buburan optimum dalam semua bahagian litar adalah diperlukan. Kirakan beban pusing balik dalam litar pengisaran yang ditunjukkan dalam Rajah S4 dan kemudian kirakan isipadu air yang perlu ditambahkan ke dalam pengisar rod dan suapan siklon.

(60 marks/markah)

5. The size distribution of the feed, underflow and overflow of a hydrocyclone classifier is shown in Table Q5. The feed consists of quartz minerals alone.

Taburan saiz suapan, aliran bawah dan aliran atas bagi pengkelas hidrosiklon ditunjukkan dalam Jadual S5. Suapan terdiri daripada mineral kuarza.

Table Q5
Jadual S5

Size (μm) Saiz (μm)	% Retained % Tertahan		
	Feed Suapan	U/F Aliran Bawah	O/F Aliran Atas
424	3.20	9.6	0.2
300	2.61	6.8	0.7
212	4.61	9.2	2.5
150	8.31	12.4	6.4
105	15.02	16.9	14.1
75	18.22	16.4	19.0
53	10.41	7.7	11.7
38	8.01	5.2	9.3
-38	29.61	15.8	36.1

The cyclone feed rate is 87.51 t/h and the fraction of water in the feed reporting to the U/F is 14.3%.

Kadar suapan siklon ialah 87.51 t/j dan pecahan air dalam suapan yang melapor kepada aliran bawah ialah 14.3%.

- (a) Draw the actual and corrected efficiency curves for this cyclone in the graph paper provided. Determine the d_{50} and $d_{50 \text{ corrected}}$ size.

Lukiskan lengkung kecekapan sebenar dan diperbetulkan (corrected) untuk siklon tersebut. Tentukan saiz d_{50} dan d_{50} diperbetulkan.

(70 marks/markah)

- (b) Assume that the cyclone feed now consists of 20% galena and 80% quartz. Assume also that all the minerals are free. The particles were broken in a ball mill in a random manner. Show roughly the efficiency curve for the galena minerals, using the same cyclone as above.

Anggap kini suapan siklon terdiri daripada 20% galena dan 80% kuarza. Anggap juga semua mineral adalah terbebas. Partikel telah dipecahkan dalam pengisar bebola secara rawak. Tunjukkan secara kasar lengkung kecekapan untuk mineral galena dengan menggunakan siklon yang sama seperti di atas.

(30 marks/markah)

6. Sketch a suitable flowsheet for a comminution circuit to break from 80% passing 250 mm to 80% passing 1 mm in three stages, including sizing operations where necessary. Indicate the machine type and the recommended reduction ratio for each stage. If the first two machines together consumed 1.0 kWh/ton when each is operated at a reduction ratio of 4, calculate the power consumed by each of the two according to the hypothesis of:

(i) Kick (ii) Rittinger (iii) Bond

Lakarkan carta alir litar kominusi yang sesuai untuk memecahkan batuan dari 80% melepasi 250 mm kepada 80% melepasi 1 mm dalam tiga peringkat, termasuk operasi pensaizian sekiranya perlu. Nyatakan jenis mesin dan nisbah pengurangan saiz yang dicadangkan untuk setiap peringkat. Sekiranya dua mesin yang pertama menggunakan 1.0 kwj/ton secara bersama apabila setiap mesin beroperasi pada nisbah pengurangan 4, kirakan tenaga yang diperlukan oleh setiap satu mesin berdasarkan hipotesis berikut:

(i) Kick (ii) Rittinger (iii) Bond

(100 marks/markah)

7. [a] Explain the differences between screening and classification process. Discuss the factors affecting the efficiency of the screening process.

Jelaskan perbezaan di antara proses penapisan dan proses pengelasan. Bincangkan faktor-faktor yang mempengaruhi kecekapan proses penapisan.

(30 marks/markah)

- [b] A comparison was required of the suitability of two types of ores for a sizing separation using vibrating screens with a separation size or cut-point of 5 mm. Therefore, samples of two ore types were screened to obtain the size distribution for each ore (see listed sizing as shown in Table Q7).

Analisis kesesuaian dua jenis bijih untuk pemisahan saiz menggunakan penapis bergetar dengan saiz pemisah atau titik poting 5 mm adalah diperlukan. Oleh itu dua jenis sampel bijih ditapis untuk mendapatkan taburan saiz bagi setiap bijih (Sila Rujuk Jadual S7).

Table Q7
Jadual S7

	Ore A	Ore B
	<i>Bijih A</i>	<i>Bijih B</i>
	% Retained	% Retained
	<i>% Tertahan</i>	<i>% Tertahan</i>
+63mm	3.3	14.2
+31.5mm	4.9	3.8
+11.2mm	14.9	7.1
+5.6mm	18.7	4.9
+1.0mm	39.1	14.0
+0.5mm	7.7	7.7
+0.25mm	6.5	20.7
-0.25mm	4.9	27.6
	100.0	100.0

Inspect the size distributions for ores A and B. Discuss the suitability of the key feed property (sizing distribution) for ores A and B as the feed to an industrial screening or sizing operation with a cut – point of 5mm. Provide reasons in your discussion on the suitability of the two feeds for screening.

Periksa taburan saiz untuk bijih A dan B. Bincangkan kesesuaian sifat penting suapan (taburan pensaizan) untuk bijih A dan B sebagai suapan kepada penapisan pengindustrian atau operasi pensaizan dengan titik potong 5 mm. Dalam perbincangan anda, berikan sebab-sebab kesesuaian kedua-dua suapan untuk penapisan.

(50 marks/markah)

- [c] Describe the meaning of the term “ideal partition curve” and sketch a graph of recovery to coarse product (y-axis) and log particle size (x-axis) to illustrate your answer.

Huraikan maksud “lengkuk sekatan unggul” (ideal partition curve) dan lakarkan graf perolehan kepada produk kasar (paksi Y) dan log saiz partikal (paksi X) dalam jawapan anda.

(20 marks/markah)