BAHAGIAN PENYELIDIKAN & PEMBANGUNAN
CANSELORI
UNIVERSITI SAINS MALAYSIA

Laporan Akhir Projek Penyelidikan Jangka Pendek

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2. **Pusat Pengajian**	:	Pusat Pengajian Kejuruteraan Bahan & Sumber Mineral
3. **Tajuk Projek**	:	**Optimization, Modeling and Simulation of Vertical Roller Mill in Cement Raw Mix Grinding Circuit**

4. **(a) Penemuan Projek / Abstrak**
(Perlu disediakan makluman di antara 100-200 perkataan di dalam Bahasa Melayu dan Bahasa Inggeris ini kemudiannya akan dimuatkan ke dalam Laporan Tahunan Bahagian Penyelidikan & Pembangunan sebagai satu cara untuk menyampaikan dapatan projek tuan/puan kepada pihak universiti)

ABSTRAK

Penggunaan tenaga semasa pengisaran bahan mentah dan klinker di loji penghasilan simen merupakan satu isu yang seringkali dibahaskan kerana 90% daripada tenaga yang digunakan akan hilang sebagai tenaga haba dan bunyi. Pengoptimumam proses pengisaran bahan mentah dan klinker akan membantu mengurangkan kos penghasilan simen. Dengan perkembangan dalam teknologi pengkomputeran, simulasi komputer adalah kaedah terbaik untuk pengoptimuman proses ini. Data loji yang baik dan boleh dipercayai (data pengoperasian, pencirian suapan dan produk) adalah amat perlu untuk pembinaan model matematik yang baru bagi tujuan simulasi. Dalam kajian ini, satu siri pensampelan telah dilakukan di litar pengisaran bahan mentah di sebuah loji pengeluaran simen dan produk klinker juga telah diambil untuk mengkaji kesan kuarza bebas dalam campuran bahan mentah terhadap saiz pengisaran dan kualiti klinker.

Data yang diperolehi daripada pensampelan loji dipadankan dengan model pengisar bebola campuran sempurna menggunakan perisisian pemprosesan mineral iaitu JKSimMet. Dua fungsi pemecahan iaitu fungsi pemecahan piawai daripada penyelaku JKSimMet dan fungsi pemecahan yang dikira daripada persamaan Broadbent dan Callcott telah dipilih untuk proses pemadanan model. Fungsi pemecahan yang dikira daripada persamaan Broadbent dan Callcott telah memberikan pemadananan yang baik untuk proses pengisaran bahan mentah simen dalam pengisar penguling menegak. Fungsi kadar pemecahan juga telah ditentukan semasa proses pemadanan model. Kehadiran kuarza bebas dalam bahan mentah simen mempengaruhi kecekapan pengisaran pengisar penguling menegak dan juga kualiti klinker.

ABSTRACT

Energy consumption during the raw mix and cement grinding process in the cement plant is the most critical issue that has been debated till now as 90% of the energy consumed will be lost as heat and noise energy. Optimisation of cement grinding process will help to reduce the production cost and with current drastic development in the computer technology, computer simulation is the best way to optimise the process. A good and reliable plant data (operational, feed and product characterisation data) is essential to build a new model. In this study, a series of sampling were conducted around the raw mix grinding circuit and also clinker samples were taken to study the effect of the free quartz content in the raw mix on the clinker.

The data obtained from the plant sampling was fitted with the Perfect mixing ball mill model using steady state mineral processing software, the JKSimmet. Two breakage functions were chosen for the model fitting process, the standard JKSimMet breakage function and the breakage function calculated from Broadbent and Callcott equation. The raw mix grinding process in the vertical roller mill could be described by the perfect mixing ball mill model and breakage obtained from the model fitting process. The presence of free quartz in clay affected the grinding efficiency of the vertical roller mill and also the quality of the clinker produced.

(b) Senarai Kata Kunci Yang Digunakan Di Dalam Abstrak

grinding, raw mix, model fitting, breakage, vertical roller mill

Bahasa Inggeris	**Bahasa Melayu**
Grinding	Pengisaran
Raw mix	Campuran bahan mentah
Model fitting	Pemadanan model
Breakage	Pemecahan
Vertical roller mill	Pengisar penguling menegak

5. Laporan Projek

EXPERIMENTAL

Two raw mix grinding circuit, each with Vertical Roller Mills were used for the study. Twelve sets of feed and product samples were obtained from the circuits. During the sampling survey all variables measured were recorded in the control room. Operational parameters such as mill feed rate, percentage of each raw material, power consumption of the mill, temperature of inlet and outlet gas and hydraulic pressure of each roller were measured. Various tests such as particle size distribution, moisture content and chemical composition of the feed and products, residue test for clay and final product samples from both mills were conducted. The free quartz content was obtained through the residue test using the 52-mesh sieve.

The model fitting of vertical roller mill was done using JKSimmet, a mineral processing simulator. The data obtained from the plant sampling was fitted with the Perfect mixing ball mill model using the steady state mineral processing software, JKSimmet. The breakage function and the breakage rate function for the VRM were determined during the model fitting process. Three breakage functions chosen for the model fitting process were the standard JKSimmet, Soft porphyry copper USA and Broadbent and Calcott breakage functions.

The perfect mixing model was fitted with two operational parameters of the VRM, feed rate and grinding roller pressure. The physical and chemical characteristic of the raw material such as the feed size, moisture content in the raw material, silica modulus and free quartz content were chosen as the parameters for the model fitting process. The breakage rate function was determined via R/D values.

Results & Discussion

Table 1and 2 show the standard deviation values of the experimental data fitted with the Perfect Mixing Model by varying the breakage function at different levels of feed rate and silica modulus respectively. Figure 1 shows the variation of particle size distribution for the experimental and the calculated values. Figure 2 shows the JKSIMmet standard, Soft Porphyry Copper USA and Broadbent and Callcott breakage function values.

Table 1: Standard deviation for breakage function fitting at different feed rate

Feed Rate	JKSimmet Standard Breakage Function	Soft Porphyry Copper USA Breakage Function	Broadbent and Callcott Breakage Function
Low	2.60	2.92	0.9248
Medium	3.54	3.49	0.9376
High	1.31	1.81	0.7525

Table 2: Standard deviation for breakage function fitting at different silica modulus

Silica Modulus	JKSimmet Standard Breakage Function	Soft Porphyry Copper USA Breakage Function	Broadbent and Callcott Breakage Function
Low	0.6012	0.567	0.5012
High	1.31	1.81	0.7525

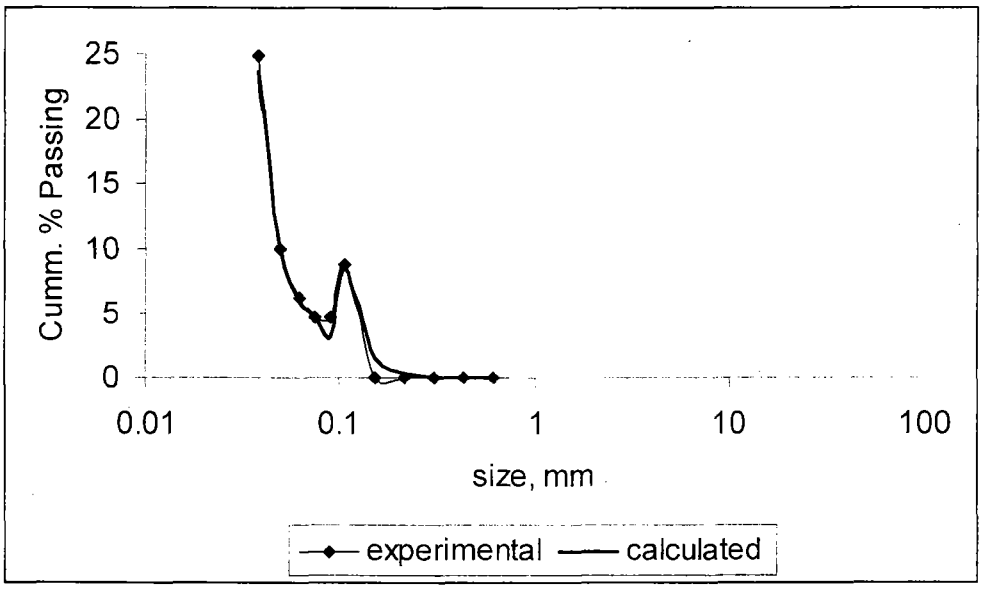

Figure 1: Particle size distribution of the raw mix (experimental and calculated)

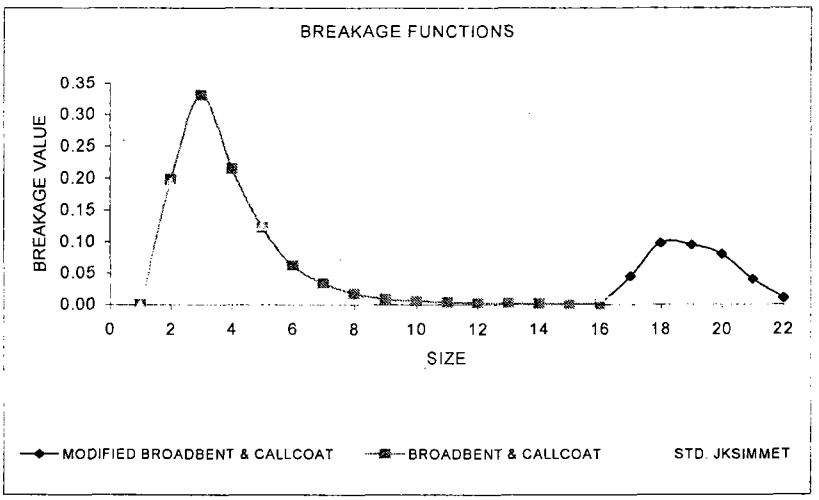

Figure 2: Breakage Function Values

The breakage function calculated from the Broadbent and Callcott equation fitted well with the raw mix particle size distribution data as it gave the lowest standard deviation compared to other breakage functions. Thus, this breakage function was used for simulation of the cement raw mix grinding data.

It was found that raw mix grinding in a VRM could be described by the perfect mixing model. In a perfect mixing ball mill the feed entering the mill would be distributed along the mill, thus being subjected to the probability for breakage. A similar situation was encountered in a vertical roller mill where the feed that has fallen on the grinding table was being subjected to the breakage process by the rollers and the entire particles would have some probability for breakage.

The Broadbent and Callcott breakage functions fitted well for cement raw mix grinding process because the values of breakage function for earlier sizes (large particle sizes) were big. Therefore, the larger feed would break more compared to fine particles. The standard JKSimmet and the Soft Porphyry Copper USA breakage functions had smaller values resulting in the larger particles that were selected for breakage having a small probability for breakage.

The value of breakage function calculated from the Broadbent and Callcott was small for smaller particles. This was a good phenomenon where the breakage function tended to break the larger particles rather than the smaller particles as the smaller particles may be fine enough to be the kiln feed.

Results of R/D* fitting for Vertical Roller Mill

In the model fitting process, the breakage rate is a constant, whereas the R/D* is the variable parameter which refers to the breakage rate function. The breakage function calculated from the Broadbent and Callcott equation was used because it fitted well for the cement raw mix grinding process. The operational parameters chosen were the mill feed rate and silica modulus. Table 6 shows the R/D* value for Vertical Roller Mill at different feed rates.

Table 6: Breakage rates at different feed rates.

Feed Rate	R/D*		
	Size 1	Size 2	Size 3
Low	4.20	5.06	5.26
High	1.99	6.16	7.21

From Table 6 it could be seen that the particle breakage rate increased with the particle size but an abnormal polar could be seen in the table, where at sizes 2 and 3 at high feed rates, the breakage rate was more than the breakage rate at low feed rates. Normally if the feed rate was high, the breakage rate should be lower. This condition may be due to the limestone which was stacked form two different sources, one with lower silica content and the other one with high silica content. For high feed rate conditions, maybe there was low silica content in limestone distributed in sizes 2 and 3. Low silica content in limestone tends to break easily compared to the high silica content limestone. Therefore, the breakage rate in sizes 2 and 3 was higher in high feed rate conditions.

Table 7 shows the R/D* values for Vertical Roller Mill at different silica modulus.

Table 7: Breakage rate at different silica modulus

Silica Modulus	R/D*		
	Size 1	Size 2	Size 3
Low	1.19	6.16	7.01
High	0.9005	0.1414	0.359

Both surveys had the same feed rate. Table 7 showed a good polar of breakage rate function. When the silica modulus increased the breakage rate of the particles decreased although the breakage rate increased with the particles sizes. This phenomenon was due to silica, which is a hard material. The hardness of silica is seven in Mohr's scale. Therefore, when the silica modulus increased the breakage rate of the cement raw mix decreased.

Conclusion

The following conclusions can be drawn from the present study:

a) Mill feed rate, silica modulus; coarse free quartz content in clay will effect the particle size distribution of the cement raw mix product.
b) Vertical roller mill was more efficient than the air swept ball mill for cement raw material grinding.
c) The raw mix grinding process in the vertical roller mill could be described by the perfect mixing ball mill model and Broadbent and Callcott breakage function obtained from the model fitting process.
d) The breakage rate function of cement raw mix was affected by particle size distribution; mill feed rate and silica modulus of the raw mix.

6. Output dan Faedah Projek

(a) Penerbitan

1. Fiesal Musa and Khairun Azizi (2003). "The Effect of Free Quartz on the Particle Size Distribution of Cement Raw Mixes". Proceedings of the 3rd International Conference on Recent Advances In Materials, Minerals and Environment, RAMM 2003. pp. 162-167. Penang .Malaysia

2. Fiesal Musa and Khairun Azizi M.A (2002). "Effect of Free Quartz Content in Clay on the Grindability of Cement Raw Mixes". *MAMIP.* Proceedings of Materials and Minerals - Post Graduate Research Papers 2001/2002, School Of Materials & Mineral Resources Engineering USM. pp. 64-66.

3. Fiesal Musa and Khairun Azizi M.A (2002). "The Importance of Grinding in Cement Manufacturing", Buletin ENGINIER JIL.05 BIL: 02, December.

4. Satu kertaskerja bertajuk "Grindability study of cement raw mix – Air Swept Ball Mill vs. Roller Mill" sedang disiapkan untuk dihantar kepada Minerals Engineering – An International Journal.

- Satu Desertasi Sarjana (MSc) telah dihasilkan dengan kerjasama Lafarge Cement, Kanthan Works. Chemor. Perak.

  "Effect of Free Quartz on the Grindability of Cement Raw Mixes and Clinker Microstructure"

(b) Faedah-faedah Lain Seperti Perkembangan, Produk, Prospek Komersialisasi dan Pendaftaran Paten

- A model that can describe the raw mix grinding process in Vertical roller mill. This model can be incorporated with programming software such as Visual Basic to cater the needs of simulation in the cement plant for optimization process.

(c) Latihan Gunatenaga Manusia

1. Pelajar MSc : Satu orang telah berijazah pada konvo USM 2003

2. Pelajar – Prasiswazah : Dua orang telah menyiapkan projek tahun akhir

7. Peralatan Yang Telah Dibeli

Tiada. Menggunakan peralatan yang sedia ada di Pusat Pengajian dan juga di Lafarge Cement Kanthan Works.

UNTUK KEGUNAAN JABATAN PENYELIDIKAN UNIVERSITI

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