Effect of Feed Amount and Composition on Blaine and Residue in Cement Mill

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Abstract

This study investigates the effect of the amount and composition of cement ball mill feed on Blaine fineness and cement residue. The collected data were obtained using a ball mill for grinding clinker and additive materials (pozzolana and gypsum) at different amounts and composition of feed. The fineness of cement was measured as specific surface by air permeability method (Blaine Method) and residue was calculated as cumulated residue on a 45 microns sieve. It was found that the cement residue increased with an increase in the amount and composition of feed while the Blaine fineness decreased. The clinker particles are substantially reduced in size to generate a certain level of fineness as it has a direct influence on such performance characteristics of the final product. This study was initiated to collect significant data to establish the proper fineness and residue cement product.

Keywords: Blaine fineness, residue, ball mill, grinding, cement.

Introduction:

The world cement production has been increasing constantly since the early 1950s, especially in developing countries [1]. Current world consumption of cement is about 1.5 billion tonnes per annum and it is increasing at about 1% per annum [2]. That increase was due to the improvement of the performance and quality of the cement. The main impact that the finish milling has on the cement's performance characteristics is achieved through the fineness properties of the final product [3]. It was showed that the cement performance characteristics depend on its fineness properties, whereas the current cement fineness requirements set the targets for the intensity of clinker reduction [3].

The grinding equipment then produces the required fineness by utilizing various parameters [3]. Lots of research work has been done examining the relationship between the portland cement particle fineness and performance properties of the cement paste such as the hydration kinetics, setting time, and others [4-10]. To describe this relationship, it is necessary to assign some numerical values to the cement fineness characteristics. Cement Fineness Characteristics Behavior of cement is strongly dependent on the properties of the individual particles, and the size effects become more important as the particles become smaller. The evaluation and precise definition of particle size are not simple tasks [11].

Physical characterization of cement, or any powder, would be much easier if all the particles were spheres and of the same size. Unfortunately, it is not the case since systems composed of identical particle sizes are extremely rare and the individual characteristics vary from one particle to another. The principal particle characteristic is its size and can be represented as a linear dimension, an area (e.g., surface area), a volume, or a mass [11]. Cement fineness is measured in two different methods the Blaine air permeability and the residue of 45 microns sieve [12]. The Blaine fineness of a cement powder is a single parameter that is meant to characterize the specific surface area and therefore the fineness of cement [13]. The relationships among these different representations depend on particle shape and, in case of mass, density [3]. There is a potential to optimise conventional cement clinker grinding circuits and in the last decade significant progress has been achieved.

This study concentrated on the effects of total grinding feed and composition of the cement fineness Blaine and residue percentage at different feed amount and clinker and pozzolana contents.

Methodology:

Grinding Mill:

The obtained data were generated using a ball mill shown in Figure 1. The mill was mounted on a milling rig and allows a wide range of mill speeds to be used. Two chamber mills are used for grinding clinker and additive materials (pozzolana and gypsum). They are typically arranged in a circuit with high efficiency separators. They grind materials up to 6500 cm^2/g according to Blaine. The mill itself is

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equipped with a lifting armoring in the first chamber with larger balls with a high comminuting effect. The second chamber is equipped with classifying armoring using smaller balls to finish grinding. The partition diaphragm is equipped with a controllable material flow so that both chambers maintain an optimum filling ratio. Materials from the second chamber are supplied to a separation circuit via an outlet wall. In case warmer materials are ground, water is sprayed into the second chamber or both chambers.

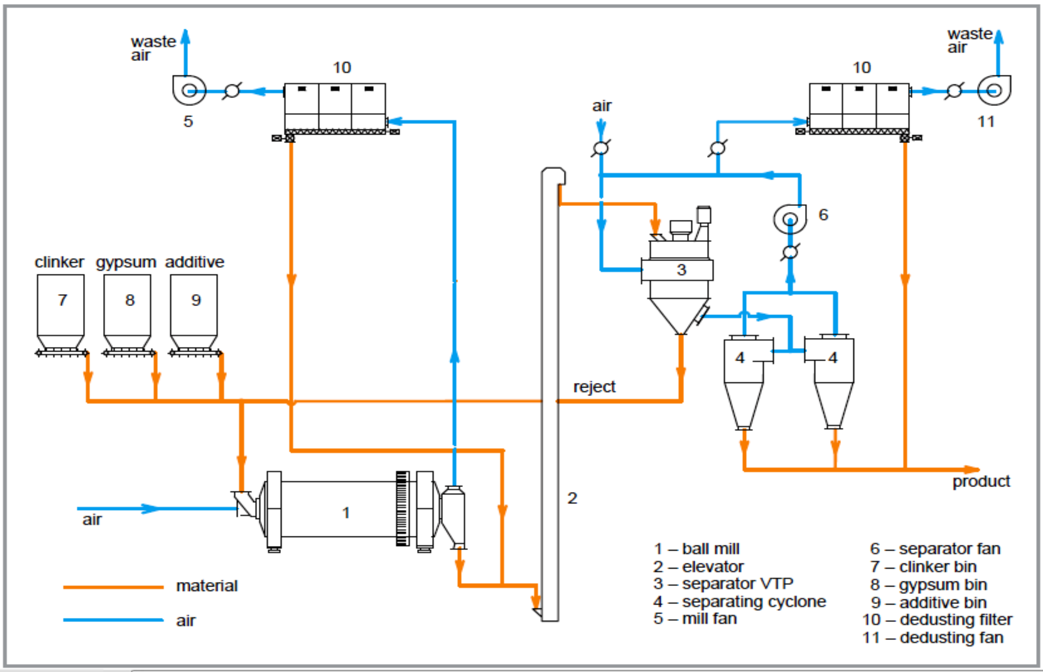

Figure 1. Description of grinding process

Air Permeability Method (Blaine Method):
The Blaine experiment is carried out to check the proper grinding of cement and the apparatus of this experiment is shown in Figure 2. The cement which is produced by an industry is checked for its quality, that either is good for a certain type of construction or doesn't posses that much strength. The fineness of cement is measured as a specific surface. The higher the specific surface is, the finer cement will be. The principle of air permeability method is used in observing the time taken for a fixed quantity of air to flow through compacted cement bed of specified dimension and porosity. Under standardized conditions, the specific surface of cement is proportional to √t where t is the time for given quantity of air to flow through the compacted cement bed. The number and size range of individual pores in the specified bed are determined by the cement particle size distribution which also determined the time for the specified air flow. The method is comparative rather than absolute and therefore a reference sample of known specific surface is required for calibration of the apparatus.

Specific surface (S) is expressed as the total surface area in square meters of all the cement particles in one kilogram of cement:

$$S = \frac{K}{\rho} \times \frac{\sqrt{e^3}}{(1-e)} \times \frac{\sqrt{t}}{\sqrt{0,1\eta}} \qquad [cm^2.g^{-1}]$$

Eq. (1)

Where: e is porosity of the bed, t the measured time [s], ρ density of cement [g/cm^3], η the viscosity of air at the test temperature and K is the apparatus constant determinate by measuring permeability of reference cement of known specific surface. The procedure is repeated three times for three samples of cement bed and the mean of the three values of K is the constant K for the apparatus. For each sample constant K is calculated as in the following formula:

$$K = S_0 \times \rho_0 \times \frac{(1-e)}{\sqrt{e^3}} \times \frac{\sqrt{0,1\eta_0}}{\sqrt{t_0}}$$

Eq. (2)

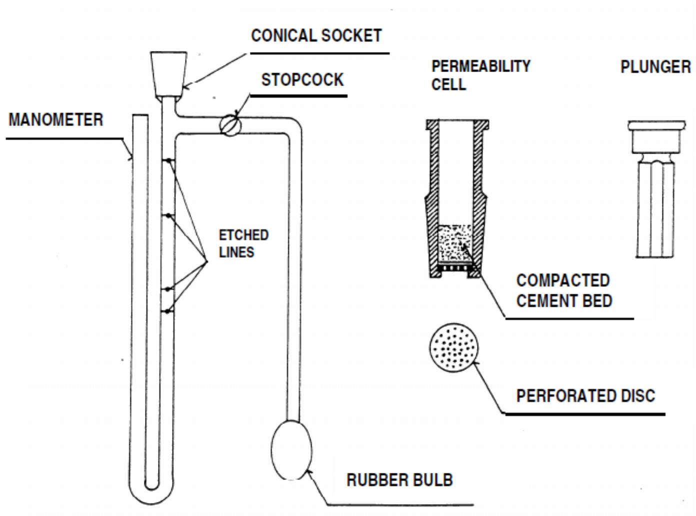

Figure 2. Blaine experiment apparatus

Residue Determination:

The cement residue was calculated as cumulated residue on a 45 microns sieve. One gram of the cement is first placed on a clean, dry 45 microns sieve and thoroughly wet with a gentle stream of water. Then, the spray nozzle is adjusted to produce a certain pressure, and the sieve containing the sample is washed with the jet of water in a circular motion for 1 minute. After this, the sieve and the residue are dried in an oven or over a hot plate. The residue is then brushed off of the sieve, weighed, and the amount of the material above 45 microns sieve is reported as a cumulative residue of the cement sample.

Results and Discussion:

The results of Blaine fineness of cement measured as specific surface at different amounts of clinker and pozzolana in feed are presented in Tables 1 and 2, respectively. Specific surface is expressed as the total surface area in square meters of all the cement particles in one kilogram of cement and calculated by Equation (1). The higher the specific surface is, the finer cement will be. The fine particles help in increasing the strength of cement. As shown in Tables 1 and 2, when the feed amount increases the Blaine fineness decreased due to a drop in grinding efficiency. Also, it was clearly found that there is a slight effect of composition on fineness. The grinding of feed with different clinker content (Table 1) has less efficiency than grinding of feed with different pozzolana content (Table 2), therefore less fineness. Pozzolana is siliceous materials which themselves are not cementitious. They contain constituents which in the presence of water form compounds that have a low solubility and possess cementing properties. Fineness or particle size of cement affects hydration rate and thus the rate of strength gain. The smaller the particle size is, the greater the surface area-to-volume ratio, and thus, the more area is available for water-cement interaction per unit volume.

Table 1: Blaine fineness of cement as a function of amounts of total feed and clinker

Clinker t/h	Gypsum t/h	Pozzolana t/h	Total Feed t/h	Blaine cm^2/g
63	5	19	87	3990
66	5	19	90	3986
69	5	19	93	3967
72	5	19	96	3943
75	5	19	99	3915
78	5	19	102	3865

Table 2: Blaine fineness of cement as a function of amounts of total feed and pozzolana

Clinker t/h	Gypsum t/h	Pozzolana t/h	Total Feed t/h	Blaine cm^2/g
72	5	16	93	3958
72	5	19	96	3935
72	5	22	99	3924
72	5	25	102	3912
72	5	28	105	3907
72	5	31	108	3899

The residue was calculated as cumulated residue on a 45 microns sieve at different amounts of clinker and pozzolana in feed. the obtained results are presented in Tables 3 and 4, respectively. It was clearly shown that the cement residue increased with the increase in the amount of feed. This is expected because the large amount of feed leads to low grinding efficiency. Therefore the roughness of cement is increased. Also, it was observed that the effect of feed composition on residue percent is slightly different between clinker and pozzolana contents. The grinding of feed with different clinker content (Table 3) has high residue percent than grinding of feed with same pozzolana content (Table 4).

Table 3: Residue of cement as a function of amounts of total feed and clinker

Clinker t/h	Gypsum t/h	Pozzolana t/h	Total Feed t/h	Residue %
63	5	19	87	0.37
66	5	19	90	0.39
69	5	19	93	0.41
72	5	19	96	0.45
75	5	19	99	0.49
78	5	19	102	0.54

Table 4: Residue of cement as a function of amounts of total feed and pozzolana

Clinker t/h	Gypsum t/h	Pozzolana t/h	Total Feed t/h	Residue %
72	5	16	93	0.42
72	5	19	96	0.45
72	5	22	99	0.48
72	5	25	102	0.50
72	5	28	105	0.52
72	5	31	108	0.53

The relationship between Blaine fineness and the residue on a 45 microns sieve at different amounts of clinker and pozzolana is shown in Figures 3 and 4, respectively. When the Blaine increases, the residue decreases. On the contrary, if the Blaine decreases, the residue on a given screen increases. The slope of the line on the clinker graph is more vertical compared to pozzolana graph. This means that the pozzolana improved grinding efficiency and properties of cement and then decreased the cost.

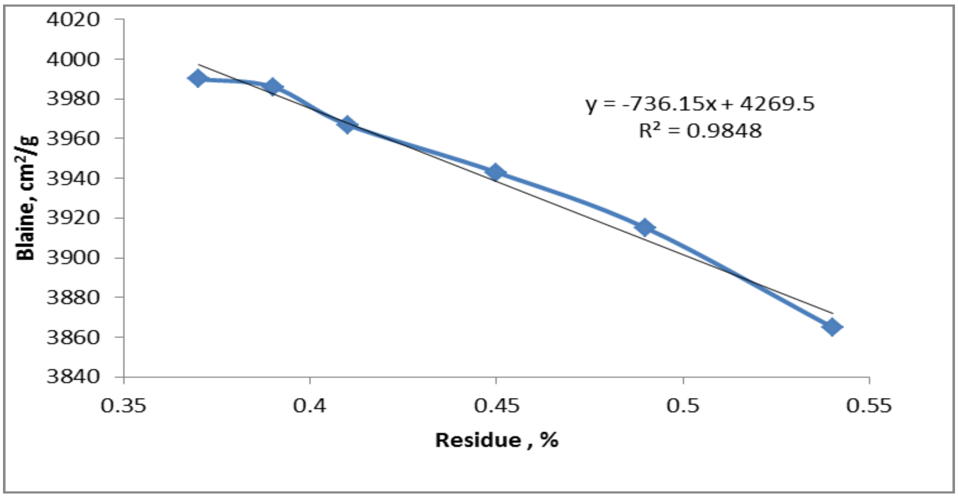

Figure 3: Blaine Versus Residue at different clinker amuonts

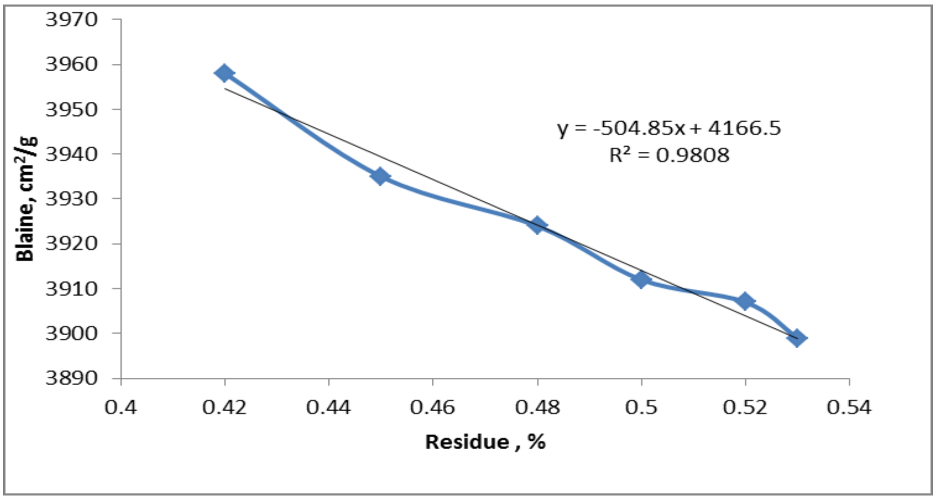

Figure 4: Blaine Versus Residue at different pozzolana amuonts

Conclusions:

From the results of this work, the following conclusions are drawn:

- The cement Blaine fineness decreased with the increase in the amount of feed while residue increased due to a drop in grinding efficiency.
- The grinding of feed with different clinker content has less efficiency than grinding of feed with same pozzolana content. This is because the pozzolana is easier to grind and it improves efficiency and properties of cement.

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تأثير كمية التغذية في النعومة في طاحونة الأسمنت وتركيبها

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الملخص

تبحث هذه الدراسة تأثير كمية التغذية في طاحونة الأسمنت في نعومة الاسمنت وتركيبها. وقد تم الحصول على النتائج باستخدام طاحونة تحتوي على كرات خاصة بطحن الكلينكير والمواد المضافة إليه (البوزلانة والجبس) عند تركيب وكميات تغذية مختلفة . كذلك تم تحديد نعومة الأسمنت من خلال قياس المساحة السطحية للأسمنت الناتج من عملية الطحن بطريقة نفاذية الهواء. أما البواقي الخشنة للأسمنت تم قياسها من خلال حساب الكمية المتراكمة على المنخل ذي المقاس 45 ميكروناً. وقد أظهرت النتائج أن خشونة الأسمنت تزداد مع زيادة كمية التغذية الداخلة إلى الطاحونة بينما النعومة تقل. يتم تقليل جزيئات الكلنكر بشكل كبير للوصول إلى مستوى معين من النعومة حيث ان لها تأثيراً مباشراً على خصائص الأداء للمنتج النهائي. وتعد نتائج هذه الدراسة مهمة للحصول على البيانات اللازمة لتحديد النعومة المناسبة الأسمنت المنتج بواقي.

الكلمات المفتاحة: نعومة الأسمنت، البواقي الخشنة ، الطاحونة ذات الكرات، الطحن، الأسمنت.