Effect of Grinding Aids in Cement Grinding

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Abstract In fine grinding of cement in a ball mill, it is sometimes impractical to grind finer in a dry state. Even though the chemical reactivity requires the material to be dry ground, it is sometimes necessary to use different breakage machines to obtain the product, but it is usually more expensive, requires more energy and reduces capacity. The economic alternative is to use a grinding aid. Grinding aid or grinding additives refer to substances which when mixed into the mill contents cause an increase in rate of size reduction and flowability. Grinding process of clinker was carried on with a laboratory scale ball mill by varying different type of grinding additives and dosage while the operating conditions of the mill was kept constant. These additives were added into mineral in certain ratio based on the mineral weight and the grinding has been done for a definite time at the same condition. Analysis were then conducted for their size distribution and compaction factor. Results shows that there were significant improvement in size distribution as the dosage and types of grinding additives changes. Different types of grinding additives were found only suitable for clinker grinding while other give no significant results. The results obtained showed that with the addition of grinding additives can improve the grindability by decreasing agglomeration and increase breakage and hence, reducing ball coating Industries application of grinding additives also give significant improvement in terms of throughput and size distributions.

1. Introduction

Grinding aid or grinding additives refer to substances which when mixed into the mill contents cause an increase in rate of size reduction [1]. These terms are very common in cement industries where it is used to increase the throughput to the mill. Grinding aid also affect the cement flowability throughout the circuits. The grinding aid facilitates size reduction so that the mill has to apply less grinding power without having adverse effect on any of the properties of the resulting cement. Another beneficial effect of grinding aids used today is to decrease compaction in storage. It is generally improves grinding efficiency, by bringing down the limit of grinding.

In dry ball milling of fine powders such as cement grinding, a common phenomenon is the slowing down of breakage as the powder becomes finer, i.e the grinding efficiency decreases with the accumulation of
fines in the mill content. This might be due to the regrowth or rebuilding of particles from smaller particles by either agglomeration involving van de Waal’s force or by direct coating of balls to give soft surfaces [1].

However, the action mechanism of grinding aids, has not been understood perfectly despite large amounts of useful information [2,3]. But from industrial experience, there is significant effect in terms of throughput and flow of material in the mill and throughout the circuits.

Cement clinker is difficult to grind and the fine grinding of this material is one of the major problems of cement industry. The benefits of any grinding aid must outweigh its cost and the grinding aid should have no detrimental effect on the downstream process of the finished product.

![Figure 1. Comparison between grinding of cement clinker with and without grinding aid (after Fuerstenau, 1990)](image)

Figure 1 shows the typical comparison between grinding of cement clinker with and without a grinding aid in a laboratory mill. As discussed in the literature [1,2,4], there was significant effect of using grinding aid in cement grinding. Grinding aids are active surface agents that counteract the agglomeration of very fine particles on the grinding media, thus inhibiting the grinding effect and therefore reducing production rates. A number of grinding aids are available on the market. The most suitable grinding aid for a certain grinding process has to be determined by full scale test runs. The use of grinding aids in both open and closed circuit systems will improve the control of the grinding process, increasing the Blaine number (finer product). These advantages usually justify the cost of a grinding aid. But some cement manufacturers refuse to use grinding aids for economic reason.

Locher and von Seebach [5] investigated the use of organics in cement dry grinding and found that the use of chemical additives does not affect the breakage of coarse material and become a factor when fine material builds up in the mill. This conclusion was in parallel to literature [4]. In their work found that grinding aids work effectively in the range of very fine grinding. The use of an additive also increases flowability of the powder and reduces the mean residence time at a given feed rate [1].

2. Experimental Work

Experimental work was divided in two parts: industrial survey and laboratory work. Industrial survey was conducted from a cement plant in Perak. The milling facilities consist of a two-compartment air-swept ball mill arranged in close circuit. The first compartment of the open circuit mill contains balls ranges from 90mm to 30mm in diameter, while for the second compartment contain 20mm ball. Samples are taken from the two-compartment ball mill in close circuit the cement grinding with and without grinding aid.
Laboratory experimental work was also conducted to study the effect of various types of grinding additives on product fineness and compressibility. Triethanolamine (TEA), Ethylene Glycol (EG) and CEMEX (commercial grinding additives) was tested at various dosage in ball grinding mill at fixed grinding condition (ball size, speed and filling ratio). The product was tested for their size distribution using laser sizer while compressibility test (Carr’s Index) was used for this study.

3. Result and Discussion

3.1 Industrial experimental work

Figure 2 shows the size distribution of the surveys conducted. The was a sudden decrease from the feed to the first point. The effect of recycle material was obvious and indicated by Point 1 and Point 2 having finer size distribution. The classification of material due to middle grate was not obvious. Only the coarse fraction indicate clear finer size along the mill. The important conclusion from these observations was that the use of grinding aids gave finer product, therefore increased the throughput (Table 1). Product from surveys 10,
11 and 12 gave finer product compared with the one without grinding aid. Survey 7 and 12 are also plotted in the graph for comparison (Figure 2)

Figure 3. The effect of grinding aid in clinker grinding

Figure 3 shows the size distribution analysis for various grinding additives at 0.1% dosage. Although the particle size analysis has resulted in the increasing of coarser particles with the increasing concentration of TEA, it shows that the powder is free flowing with higher concentration of TEA. The increasing of coarser size is because of the agglomeration of particles during the grinding process and most probably because of the concentrations of the TEA used in this experiment is too high until it can’t meet its optimum percentage usage. However, from the observation of ball coating, it has also shows that with the addition of grinding
additive, it has results in less ball coating and mill lining coating and thus, proving that the flowability of the clinker powder has increase with the addition of grinding additive.

**Figure 4.** Size distribution analysis for various grinding additives at 0.1% dosage.

The particle size distribution with the addition of CEMEX results in the movement of curve towards finer size region with the increasing percentage of CEMEX except for 0.02% addition of CEMEX. This is because at the 0.2% concentration, the particles tend to agglomerate and make the size coarser but with the increasing of CEMEX concentration, it has results in finer size of particles. The adsorption of the grinding additive to the surface of particles has decrease the cohesive force and thus, prevents the agglomeration of particles. The increasing in the flowability can be proved when there is less ball coating (Figure 5), mill lining coating and less agglomeration occurred that can be showed with the movement of curve towards the finer particle size.

The particle size distribution with the addition of EG has results in the movement of curve towards a coarser size region with the increasing percentage of EG. The agglomeration of particles with the addition of EG has results in the less breakage of cement clinker. Although the particle size analysis has resulted in the increasing of coarser particles with the increasing concentration of EG, the compressibility index has shows that the flowability increase with the increasing of percent grinding additive used. It increasing of flowability can be proved by looking at the ball coating and mill lining coating observation. It has shows that with the addition of EG it has results in less ball coating and mill lining coating.

**Figure 5.** Ball and lining coating without grinding additives.
Figure 6 shows that at 0.1% TEA, EG and CEMEX, EG and CEMEX give the lower compressibility index compared to TEA. Thus, we can conclude that EG and CEMEX has higher flowability properties compared to TEA. The flowability of CEMEX and EG are almost similar but in term of particle size distribution, the cement clinker product with CEMEX addition gives finer size than EG.

4. Conclusions

In conclusion, with the addition of correct type of grinding additive in a small amount to the cement clinker, it will results in a finer ground product compared to grinding without an additive. For the current work, CEMEX was found to be the most suitable. The decreasing in the compressibility index number with the increasing of additive concentration may possibly due to the reduced tendency of compaction and the agglomeration of the ground cement clinker. The flowability of the cement clinker powder will also increase with the increasing of grinding additives concentration. It is hoped that the outcome of the work will help the cement industry to justify the use of grinding aids in their operations.

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