CEMENT ADDITIVES
POLYCARBOXYLATE POLYMER POWERED GRINDING EFFICIENCY

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BUILDING TRUST

Jorg M. Schrabback, Sika Services AG

Polycarboxylate polymer-powered grinding efficiency

Reduced CO_2 emissions at constantly high quality levels and production values are today's challenges in cement production. This article focuses on how cement manufacturers can benefit from polycarboxylate polymer powered grinding and separating efficiency.

The CO_2 emissions resulting from the calcination process during clinker production are unavoidable. Therefore, a primary focus for the cement industry is the substitution of clinker with secondary cementitious materials (SCM). However, the higher the amount of clinker replacements the slower the strength development of these blended cements. One of the main topics that this paper discusses is the issue of compensation for this loss in strength.

There are currently several options to improve the strength development with locally available raw materials, such as:

- Higher Blaine fineness of cement;
- Optimised gypsum content;
- Chemical activation of the hydration process with cement additives;
- Optimised particle size distribution (PSD) of the cement.

Benefits of improved cement grindability

The possible influence of improved overall fineness and optimised particle size distribution is usually neglected, since the grinding and separating efficiency is often deemed to already be at its limit. Indeed, the grinding process has been subject to a large number of improvements over the last few decades. Completely new mill systems for pre- and fine-grinding have been developed, and furthermore, the most widely spread ball mill system has seen several steps of improving its efficiency that have resulted in increased production rates and reduced specific energy consumption levels (see Figure 1).

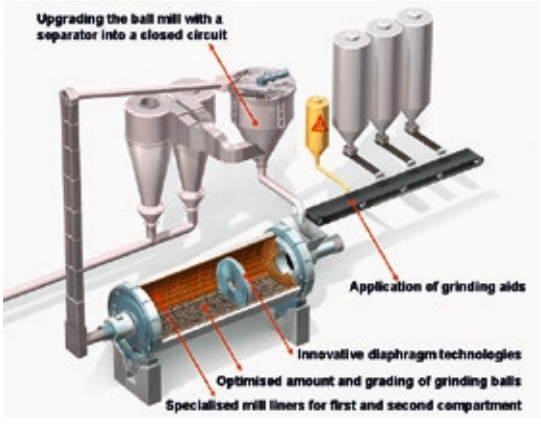

Figure 1 (right): Improvements of clinker grinding.

Nevertheless, if it were possible to further improve the efficiency of the cement grinding and separating process, this could be used to:

- Further increase the production volume of the mill;
- Reduce the specific energy consumption;
- Generate additional sales and contributions;
- React flexibly to market demands;
- Increase cement quality and therefore increase the volume of clinker replacements.

All-in-all, a further production increase would increase the cement manufacturer's profitability. Polycarboxylate polymer (PCE) powered grinding aids are one additional opportunity to allow for a further improved grinding efficiency and cement quality.

Influences on the mill system efficiency

To understand how grinding aids affect the efficiency of the grinding and separating system, it is important to understand the comminution process and its different influencing factors (see Figure 2). In the case of clinker grains, the impact of grinding balls in a rotating ball mill on the material to be ground leads to the creation of cracks in the grains. During this process, undesired charges are created on the new surfaces, which then cause an electrostatic attraction of the cement particles. The higher the targeted fineness, the more surface charges are generated.

These electrostatic attraction forces on the particle

Figure 2 (left): Influencing factors in the grinding process

surface cause decreasing grinding and separating efficiencies due to the following aspects:

1. Cracks in the particles that are starting to develop close again directly;
2. Ground particles stick to grinding equipment (coating effect) and soften the impact of the grinding balls;
3. Sufficiently ground particles form agglomerates that are detected by the separator as coarse particles and are consequently returned as rejects to the mill (see Figure 3). The resulting over-grinding effect contributes to a high specific surface – and the resulting side effects – and little towards strength development.

Collectively, these effects lead to a lower production rate and hence a higher specific energy consumption per tonne of cement.

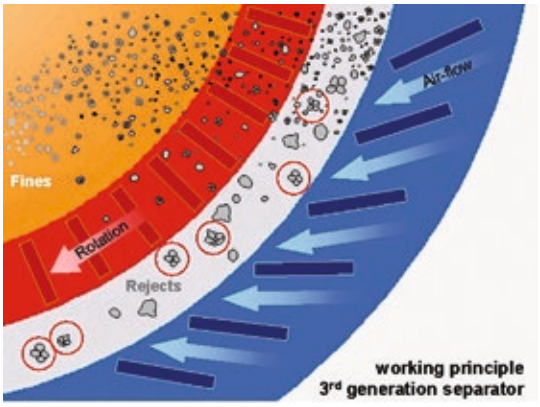

Figure 3 (left): Agglomerations reduce separator efficiency.

Effects of grinding aids on the grinding process

Grinding aids are usually added at low dosages in a typical range of 0.02%-0.05% onto the mill feed or directly into the mill. They are based on substances of high polarity that lead to a better particle dispersion due to the saturation of the surface charges. This causes three different effects:

1. Grinding aids ensure that the crack formation in the cement particles continues to develop. This ensures that the cracking of particles leads to a faster comminution;
2. The use of grinding aids reduces the coating effect and leads to blank mill internals. The resulting intensified impact of the colliding balls enhances the grinding efficiency;
3. Particles that are treated with grinding aids are better dispersed when entering the separator. The better the powder dispersion, the higher the probability that the particles will be detected with their actual dimensions. This increases the separator efficiency and results in a more favourable particle size distribution with lower content of overground particles.

Grinding aids positively affect the grinding and separating process, which allows the achievement of the desired fineness of cement on an economically viable scale and hence maximises the cement manufacturer's profitability.

Effects of polycarboxylate polymer-powered grinding aids

State-of-the-art technologies for grinding aids include the use of amino alcohols and glycols, which can be used in formulated products, but also as pure raw materials. With the successful use of polycarboxylate polymers in modern concrete technology as powerful superplasticisers and high range water reducers, the concept has also been developed to use these polymers in the cement grinding process. Based on the knowledge of its design and production, Sika has developed a polycarboxylate polymer-powered grinding aid technology, which is able to improve the performance of traditional amino alcohol and glycol-based grinding aids.

The major benefit versus traditional grinding aid technologies can be measured in a distinct production increase. This improved efficiency of the mill system helps to achieve strength enhancements and hence higher clinker replacements with increased cement fineness and a more favourable particle size distribution at constant production values. Therefore, this new cement additive technology can be categorised as a grinding aid with performance enhancing characteristics, or so-called quality improvers.

Case study of PCE powered amino alcohol based grinding aid technology

The data of this plant application shows a 13% production increase of a traditional amine based grinding aid versus the blank production at a constant fineness. The polycarboxylate polymer-powered grinding aid SikaGrind-820 allowed for a production increase of 20%, which is a significantly increased efficiency of the grinding and separating system (Figure 4).

The reason for a production increase had two reasons: to save specific energy consumption and to increase the capacity of the grinding installation. In this case, the specific energy consumption could be reduced by 8kWh/t in combination with an extra production potential of 60,000t/y.

Additionally, this production increase creates the opportunity to enhance quality with higher fineness and a more favourable PSD at a constant production rate. This would allow the replacement of up to 5% of clinker with SCM, which would consequently decrease the carbon footprint and increase the cement manufacturer's profitability.

The second plant trial example confirms the improved performance of polycarboxylate polymer-powered grinding aids. In this case, the innovative technology of SikaGrind-820 has enabled a significant production increase of up to 20%. The traditional amine-based product reached its limit with an 8% production increase at a dosage of 0.03% (Figure 5). Moreover, these results demonstrate how flexible the production process can become if the mill output can be economically correlated to the grinding aid dosage.

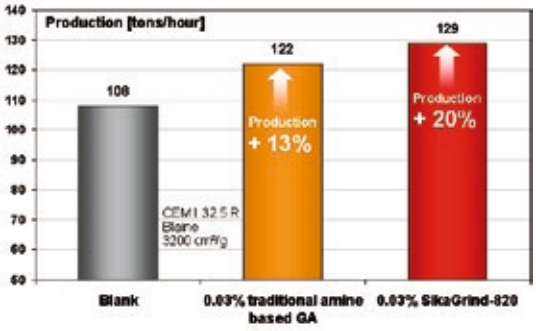

Figure 4 (right): PCE powered GA increases the production significantly.

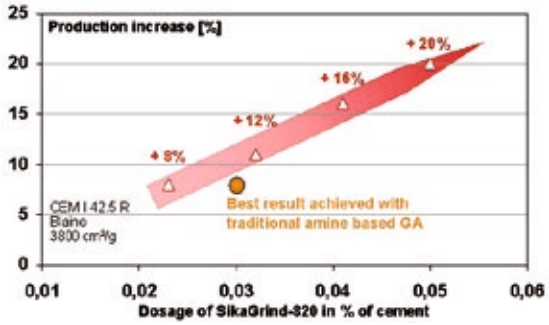

Figure 5 (right): PCE powered GA allows for flexible production planning.

Case study of PCE powered glycol-based grinding aid technology

The third plant trial example demonstrates that an upgrade in grinding efficiency is also possible in the traditional glycol-based grinding aid technology (see figure 6). In this specific case, 0.025% of a traditional glycol-based grinding aid achieved a production increase of 9%, while the same dosage of the PCE/glycol formulation easily achieved a production increase of 16%.

Polycarboxylate polymers improve the performance of the traditional grinding aid technologies of amino alcohols and glycols and allow for a further increase of the production rate. This additional production increase offers the opportunity to target a higher fineness and more favourable PSD at constant production rate.

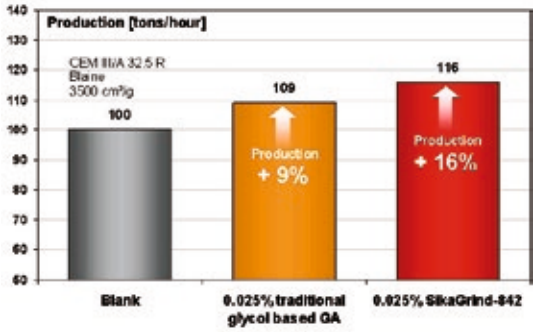

Figure 6: PCE powered GA increase the production significantly.

The resulting enhanced quality allows plants to reduce their clinker content and hence to decrease their carbon footprints while increasing the cement manufacturer's profitability.

Conclusions

Grinding aids have a positive effect on the grinding and separating process and allow the desired fineness of cement to be achieved in the most economic way. Polycarboxylate polymers improve the performance of the traditional grinding aid technologies of amino alcohols and glycols and allow a further increase of the production rate.

Increased efficiencies of the mill system lead to much more than just reduced specific energy consumption. It can also be used to achieve strength enhancements with increased cement fineness and optimised particle size distribution at constant production values. The potential clinker reduction minimises the carbon footprint.

Sika's polycarboxylate polymer-powered grinding aid technology used for the SikaGrind-800 series offers solutions for individual challenges and also maximises the cement manufacturer's profitability.