Improvement of cement performances through the use of grinding aids in vertical roller mill

P.D'Arcangelo, M.Magistri – Mapei SpA, Milan, Italy

Abstract

Due to the stringent requirement of energy saving, the use of vertical roller mills for cement grinding is now common. Even though the reliability and operation stability of modern VRM is very good, there is still room for further improvements with the use of specific cement additives formulated for the use in this type of grinding systems. In this paper we describe in details an industrial test performed during the production of slag cement in a vertical mill, showing how the use of grinding aids can improve both process parameters and cement quality. The positive effects of chemical addition to particle size distribution and separator efficiency are discussed in details.

Introduction

In 2010 the worldwide cement production is estimated to have reached 3,3 billion tons, with more than 70% of the total produced in Asia [1]. In parallel to this huge increase, the need of cost reduction has become mandatory. As a result, mainly due to lower specific energy consumption (measured in kWh/t of produced material) and higher production (t/h) values, vertical roller mills (VRM) are slowly, but steadily, outnumbering horizontal ball mills.

Vertical cement mills are able to reach production values which are significantly higher than the ones achievable with traditional ball mills, in some cases up to 300 t/h. Empirically, It can be estimated through a simple heat balance that in ball mills only 10% of the energy is used to increase cement fineness, the rest being dissipated basically in form of heat. A VRM allows the exploitation of around 30% of the energy supplied: this results in a lower energy consumption, in terms of kWh/t.

In addition, a VRM offer a greater versatility than a traditional ball mill: the space is reduced, having grinding and separation units gathered in the same machinery, gas flow is higher, allowing the use of material with higher humidity content.

Nevertheless, vertical mills also present certain disadvantages, if compared to traditional grinding systems. High pressures of the roller presses are required in case high Blaine values are desired, and a significant amount of water has to be added in the grinding process in order to keep the vibration level of the whole grinding system low at any time. In some cases, an external heat supply is needed to eliminate the water used to stabilize the grinding bed and avoid negative effects of partial hydration of clinker and insufficient dehydration of gypsum.

Improving grinding in VRM

There is the possibility of further improvement of cement grinding in VRM. As described elsewhere [2], the use of grinding aids specifically formulated for the use in vertical roller mill allows the reduction in vibration, leading to the following advantages:

- possibility of fresh feed increasing and higher mill output;
- reduction of water, with consequent decrease of gas temperature and hest needed;

In addition, the use of a suitable grinding aid can improve the particle size distribution of cement and positively influence clinker hydration, thus improving the cement quality. Here we describe in details the positive effects of the use of a cement additive during slag cement grinding in VRM.

Case history

Mapei has recently carried out an industrial trials on a vertical mill type LM 35 2+2 with the purpose of testing MA.G.A./VM 10, one of the newly developed cement grinding additives for vertical rollers mill.

The present industrial test has been performed with the objective of enhancing the compressive strengths of a blended cement with a high slag content. All the main cement characteristics are reported as follows:

Table 1: Cement production properties.

Cement type	CEM III/B 42,5 N
Blaine	4500 cm^2/g
Recipe	Clinker 33%, Gypsum 2%, Slag 65%
Mill output	57 t/h
Compressive strengths	
2 days	11 MPa
7 days	30 MPa
28 days	43 MPa

After introducing MA.G.A./VM 10 at a dosage of 400 g/t (0,04%) directly sprayed on the grinding bed, the following positive effect have been observed:

- Mill output increase by 12%: from 57 to 64 t/h
- Energy saving by 9%: from 30 to 27,6 kWh/t
- Compressive strengths improvement at all ages

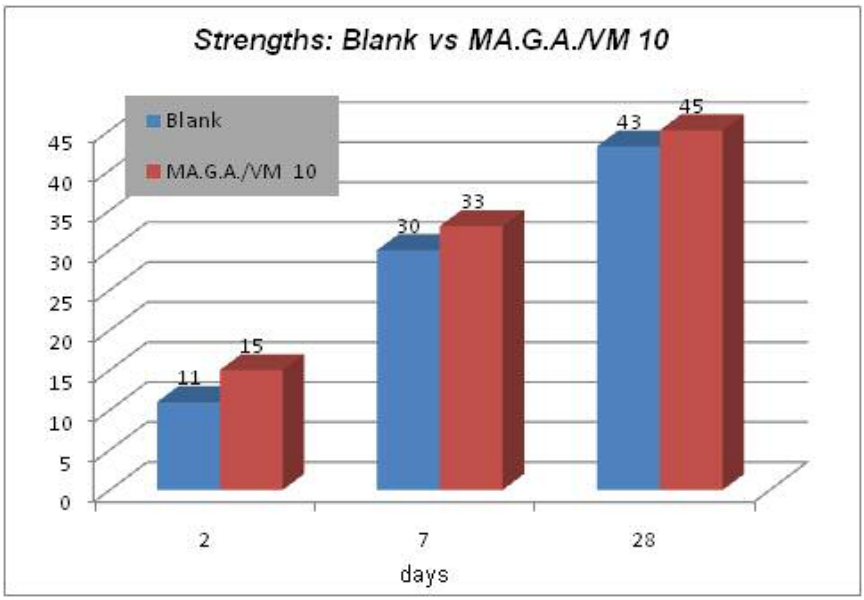

Figure 1: Compressive strengths comparison.

Beside the well known chemical interaction between the cement and the additive, another critical contribution to the mill output increase and the cement strengths improvement is represented by the two following improvement obtained with the use of MA.G.A./VM 10:

- Enhanced classifier performances
- Improved particle size distribution

Enhanced classifier performances

The most common method to evaluate the classifier's performances is the *Tromp Curve*, which is plotted combining the particle size distribution of the three streams around the separator: feed, reject and finished product.

Differently from ball mills, in the vertical roller mill the separator is inside the machine and only fine and rejected materials can be collected. The feed is calculated assuming a reasonable circulating load in the range of 8 – 12.

The graph (Figure 2) illustrates the two Tromp Curves achieved with MA.G.A./VM 10 and without any grinding additive.

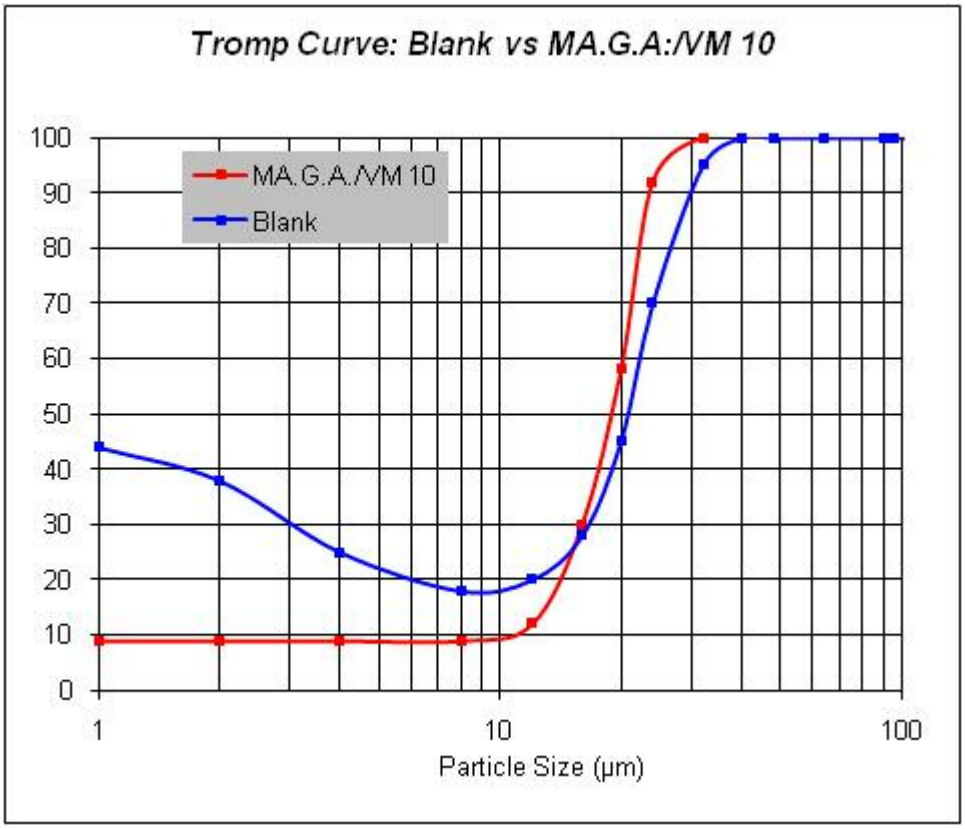

Figure 2: Tromp Curves comparison.

The comparison is done analyzing the most important parameters as showed in the following table:

Table 2: Most significant parameters of the Tromp Curves.

	Blank	***MA.G.A./VM 10***
By pass	15%	9%
Imperfection	0,26	0,16
Acuity limit	18 µm	21 µm

The above parameters show a general better performances of the separator while using the grinding aid MA.P.E./VM 10.

A very significant but uncountable phenomena is observed looking at the Tromp Curves in the finest fraction (left side), where we can clearly see how the grinding aid has avoided any agglomeration effect on the cement particles produced and fed to the separator.

Improved particle size distribution.

It is well known that during the cement hydration process the major contribution to the strengths development is provided by the finest particles, and in particular those particles in the range of 4 – 30 µm. The particle size distribution (PSD) in the two different grinding conditions is reported in figure 3.

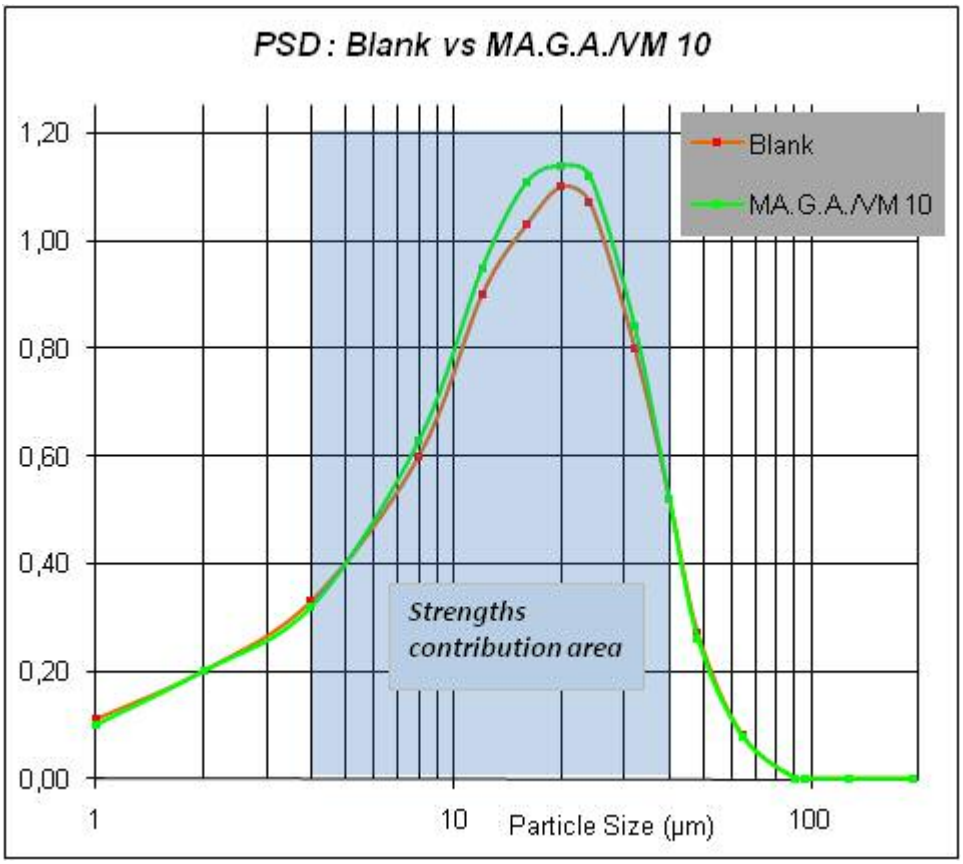

Figure 3: Particle size distributions comparison.

The density of the particles in the above mentioned range is higher when adding MA.G.A./VM 10 during the cement manufacturing: together with the chemical effect of the additive, this can be considered another reason of the strengths improvement at all ages.

Conclusion

In addition to the increase of mill output due to the stabilization of grinding bed, the effect of grinding aids on vertical roller mills can be noticed in terms of improved efficiency of the separator and better particle size distribution.

Bibliography

[1] Cembureau Activity Report 2009, available on-line at (last access Sept. 2011): http://www.cembureau.be/sites/default/files/Activity_Report_2010.pdf

[2] P.Recchi, M.Magistri, P.D'Arcangelo: "Facilitating cement grinding in vertical mills", ZKG International, issue 10/2010.