A NOVEL TECHNOLOGY FOR CEMENT GRINDING IN VERTICAL MILLS

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Abstract:

In the cement industry, the necessity of continuous improvements in the grinding process and the related cost reduction has promoted the diffusion of vertical cement mills worldwide. These particular mills present a vast series of advantages with respect to traditional, horizontal ball mills. Nevertheless, for reasons which derive principally from a different ventilation, "traditional" grinding aids don't seem to be able to provide the same performance enhancements which are achieved in horizontal ball mills. The present article describes a novel class of grinding aids developed especially for vertical mills. Furthermore, an innovative dosage technology which substantially increases the performances of these products is also described. The combined effect of these two distinct aspects constitutes an efficient, new technical approach for cement grinding in vertical mills.

Introduction – importance of vertical mills in the modern cement production industry:

Mainly due to lower specific energy consumption (measured in kWh/t of produced material) and higher production (t/h) values, vertical cement mills are slowly, but steadily, outnumbering "traditional", horizontal ball mills. The immediate advantages of such mills can be easily summed up in the following key-points:

- vertical cement mills are able to reach production values which are significantly higher than the ones achievable with traditional ball mills. As the latter ones are able to reach an indicative maximum of 180-200 t/h, vertical mills can provide up to 300 t/h.
- lower energy consumption, resulting in a lower specific cost (€/kg).
- while traditional mills have to be first assembled by the manufacturer and then transported to the industrial site with all the resulting costs as well as logistical problems, vertical mills are usually build "on-site". This aspects permits to reach mill sizes (and therefore production values) which are not achievable in the case of traditional ball mills.
- vertical mills offer a greater versatility than traditional ones: for example, intermediate cleaning-silos are not necessary, as the transition times between different cement types/compositions are significantly shorter if not inexistent.
- additionally, vertical mills are less sensitive to the eventual high-humidity content of raw materials (given a sufficient energy source is present).

Nevertheless, vertical mills also present certain disadvantages, if compared to traditional grinding systems. These aspects can be summed up in the following key-points:

- high pressures of the roller presses are required in case high Blaine values are desired.
- vertical mills are more sensitive to materials which present a very high fineness (the threshold is set around a maximum of 50% material < 4 mm).

- 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. This aspect has major repercussions on the cement temperature, therefore an external heat supply is needed to guarantee a certain exit temperature, thus increasing the specific production costs.

Effects of traditional grinding aids on the performances of vertical mills:

Similarly to the case of traditional mills, also in vertical mills the use of grinding aids, i.e. polar compounds - or mixtures thereof- which reduce the surface charges resulting from the grinding of cement's raw materials, permits to achieve performance targets (e.g. fineness, production, compressive strengths, etc.) which are usually very difficult to reach in absence of the aforementioned substances. The positive effects of grinding aids are such that nowadays, the manufactures of cement mills themselves pre-install insertion systems for these products. This has recently happened to be the case also for vertical grinding systems.

Nevertheless, our practical experiences on the field have highlighted the fact that traditional grinding aids (i.e. grinding aids developed for tubular ball mills) have shown themselves to be dramatically less efficient, when not efficient at all, when introduced in vertical grinding mills. This has happened to be the true also in the case of the very same product utilized in the two different industrial scenarios.

After careful observations and investigations performed by the Mapei Technical Assistance Group, it has been concluded that this significant difference in behavior has to be related to a couple of causes, where the most determining one is, with all probability, the different ventilation concept applied in vertical mills. More in detail, ventilation (expressed as an air/material ratio) in vertical mills is significantly stronger in vertical mills than in traditional ones. As a result, when traditional grinding aids are introduced in standard insertion points, such as on the raw materials' conveyor belt and/or directly inside the cement mill, a "stripping" phenomena takes place, which physically eliminates a major amount of grinding aid before it can be able to express its efficacy during the grinding process itself. Additionally, the higher ventilation in vertical mills also heavily promotes the early evaporation of the grinding aid in case of traditional introduction systems.

The Mapei VM series – grinding aids specific for vertical mills:

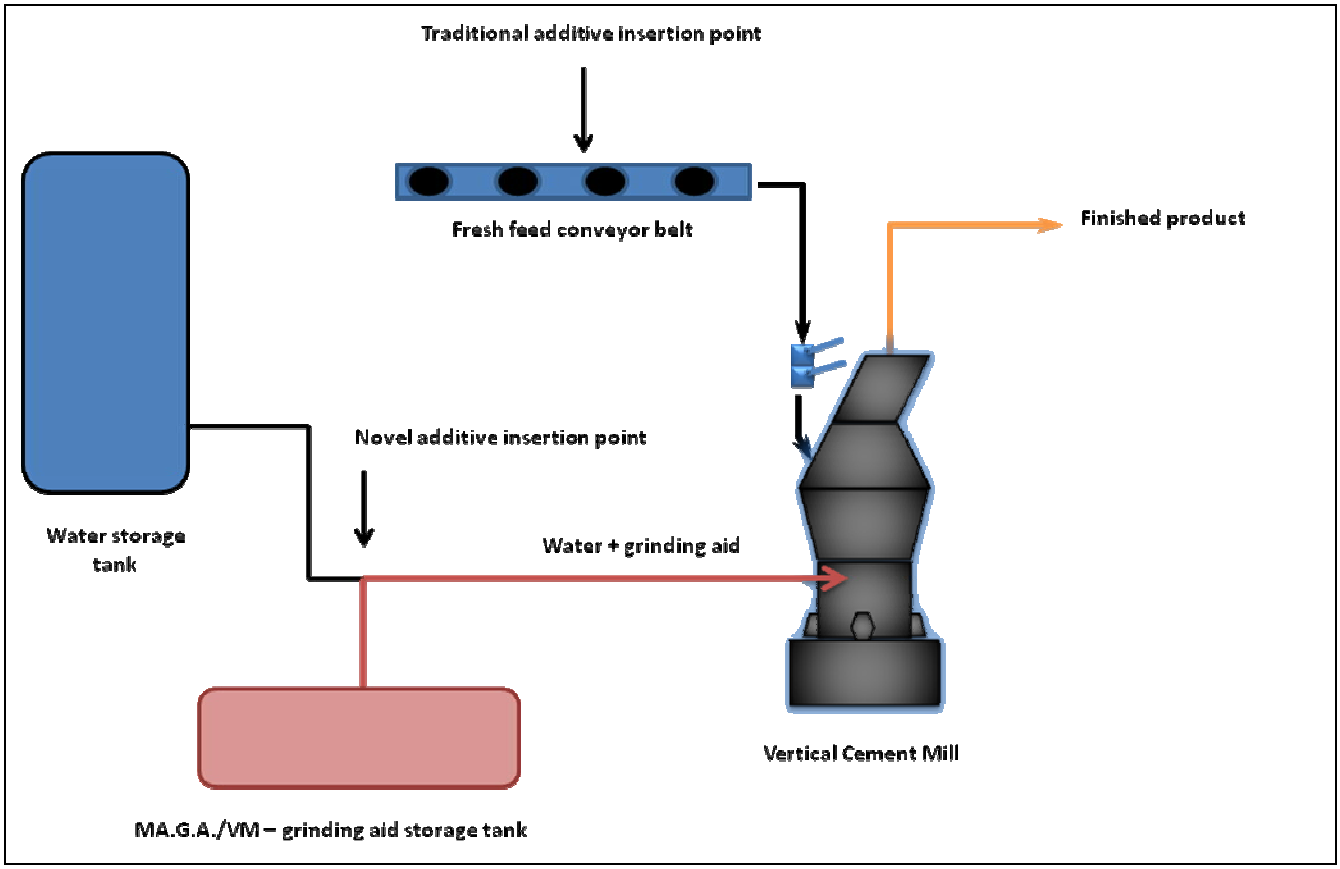
Taking into account the increasing diffusion of vertical mills in the cement production industry as well as the aforementioned technical issues which derive from utilizing traditional grinding aids in vertical mills, the Mapei Cement Additives Division R&D has developed a novel class of grinding aids especially for the use on vertical systems. This particular products contain, in addition to "classic" compounds like ethanolamines, glycols, inorganic salts, etc., a certain amount (ranging from 3 up to 10 % in weight) of a special blend of high-boiling compounds and thickening agents.

The characteristic low-volatility of such compounds assures that these grinding aids do not suffer from the high ventilation standards of vertical mills and remain unchanged until they can take part in the grinding process itself. Additionally, the peculiar chemical activity of ethanolamines, glycols, inorganic salts and their effect on the compressive strengths and cement fineness remains completely unaffected by the presence of such substances.

Due the reasons mentioned in the previous paragraph, the insertion point of the grinding aid plays a crucial role in the case of vertical mills. During several industrial trials in various cement plants, Mapei has developed an innovative introduction system which is able to prevent the stripping phenomena caused by the high ventilation, thus maximizing the positive effects of the Mapei VM additives. As is widely known,

cement grinding in vertical mills requires the presence of a continuous water jet in order to stabilize the bed of grinding material and therefore prevent the development of excessive vibrations. The water required for this task is stored in normal tanks and pumped directly inside the mill on the grinding table, through a dedicated pipeline. The particular technology developed by Mapei consists in introducing the grinding aid in the water pipeline before it enters the mill. In this way the flux of grinding aids, together with water, is forced directly under the rollers. In this way the additive is able to be immediately effective in the grinding process.

The Mapei introduction system is described in the following scheme and depicted in the following pictures:



Scheme 1 - Representation of the new insertion point as proposed by Mapei

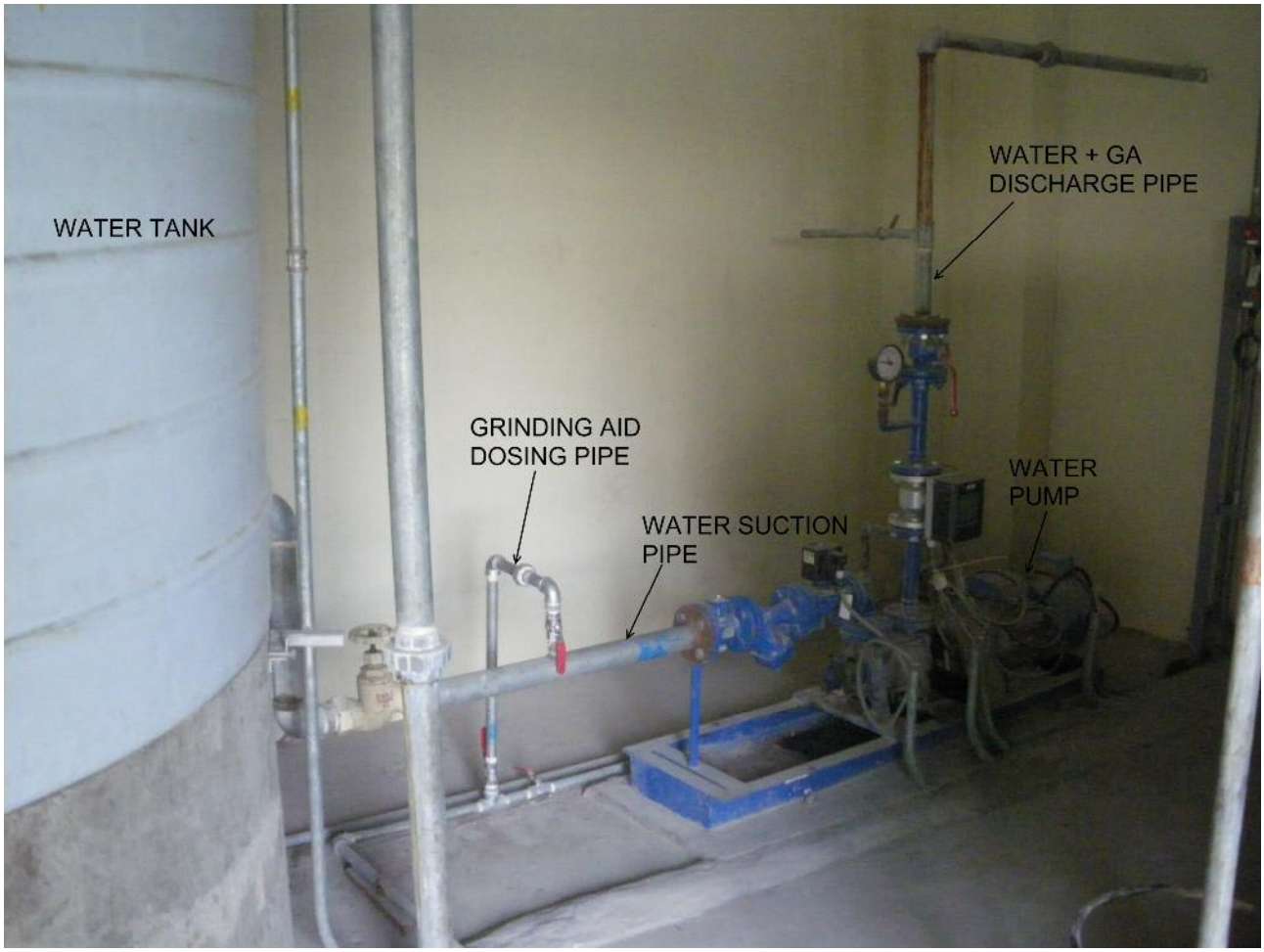


Figure 1 - Description of the introduction technology

Figure 2 - By utilizing the water pipeline, the grinding aid enters the mill directly under the roller presses

In order to demonstrate the efficacy of the new technology described in the present article, i.e. the combination of additives from the Mapei VM series and the new introduction system, we report the results of one particularly representative industrial trial which has been performed in a major Middle-Eastern cement plant during April 2010.

Case study: traditional grinding aid vs. MA.G.A/VM 12 in a vertical cement mill:

Experimental:

The average running conditions during the industrial trial with the MA.G.A./VM 12 grinding aid were as follows: *Vertical mill model*: LM 56 3+3 C/S; *Nom. Diam.:* 5600 mm; *number of rollers:* 3+3; *power installed:* 5300 kW; *power absorbed:* 3500 kW; *ventilation:* 680.000 m^3/h; *mill ΔP:* 50 mbar; *water injection:* 2,1%; *roller pressure:* 75 bar.

According to the European standard UNI EN 197-1, a CEM I-type cement (92% clinker; 4% gypsum; 4% limestone) has been produced under four different grinding conditions: blank (no additive has been introduced), with a reference product (a traditional grinding aid), with the same reference product dosed directly on the grinding table (in accordance with the introduction system described in the following

paragraph) and finally with an additive from the VM series, the MA.G.A./VM 12. This product is both a grinding aid and a performance enhancer on the early as well as late compressive strengths. Pure grinding aids, performance enhancers, workability enhancers and hexavalent chromium reducing agents, specifically developed for the use in vertical mills, are also already available.

Data about cement production parameters as well as cement quality are reported in the following chart.

CEMENT PRODUCTION PARAMETERS:				
Parameter:	***Blank:***	***Reference product dosed on conveyor belt:***	***Reference product dosed on the grinding table:***	***MA.G.A./VM 12 dosed on the grinding table:***
Mill feed (t/h):	173	175	190	200
Additive dosage (g/t):	-	250	250	250
Total energy absorbtion (kWh/t):	32.0	30.1	29.5	28.1
Avg. vibration (mm/sec):	2-4	2-4	2-4	2-4
CEMENT QUALITY PARAMETERS:				
Blaine (cm^2/g):	3487	3500	3507	3546
Residue 45µm (%):	8.0	7.9	7.8	6.4
C. strength after 2 days (MPa):	25.4	25.6	26.6	28.0
C. strength after 7 days (MPa):	37.0	38.1	38.7	39.2
C. strength after 28 days (MPa):	46.1	46.3	47.6	50.7

As can be clearly seen, the reference product dosed in traditional insertion points (in this case on the clinker conveyor belt) shows little or no improvement on the production process and cement quality. The insertion of the same reference product at the same dosage together with the water jet directly under the rollers already provides a certain improvement, demonstrating the validity of this new introduction technology. Nevertheless, the MA.G.A./VM 12 grinding aid clearly stands out and shows strong improvements of the mill production as well as on the cement quality. A comparison between the different compressive strengths which have resulted from the four different scenarios is reported in the following chart:

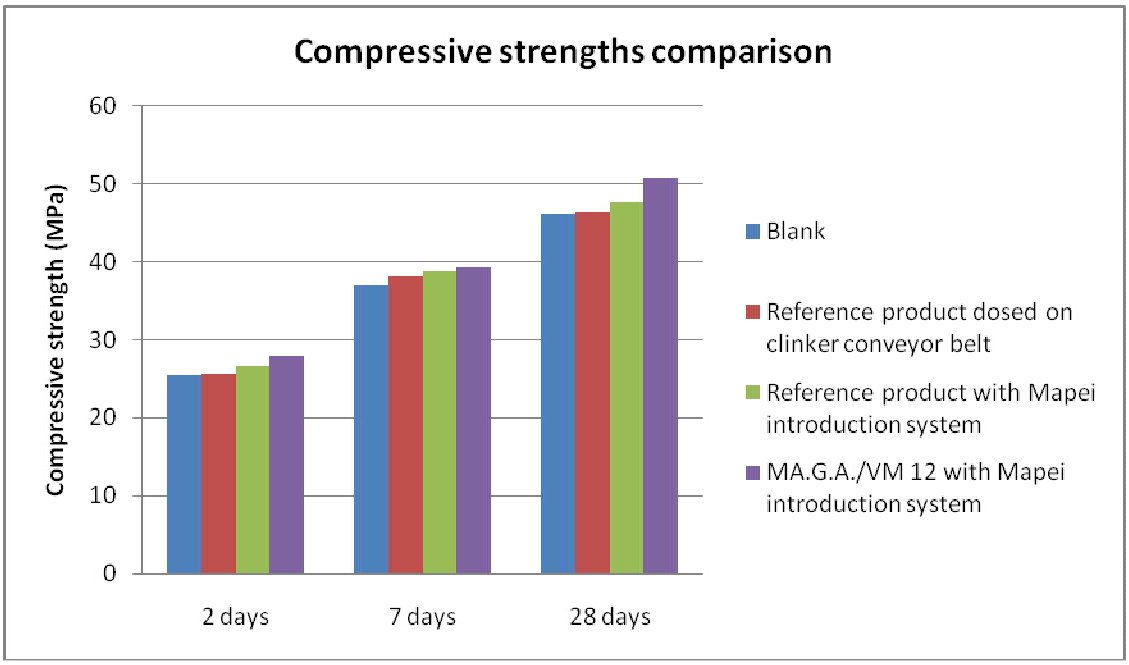


Figure 3 - Comparison of the compressive strengths which resulted from the four different grinding scenarios

Conclusions:

A novel class of grinding aids specific for vertical mills has been presented. The development of such additives has been performed on the basis of technical difficulties experienced by cement producers worldwide when using traditional grinding aids. Additives from the MA.G.A./VM series, coupled with the innovative introduction system developed on the field by Mapei technicians, have proven themselves to be able to overcome these particular issues. The resulting performances, in terms of compressive strengths enhancement, fineness/production increases etc, are comparable, when not superior, to the ones characteristic of traditional cement additives utilized in a horizontal mill-based production scenario.

The efficacy of this new grinding technology has been demonstrated through the data collected during one of the many industrial trials which were performed with these particular products.