

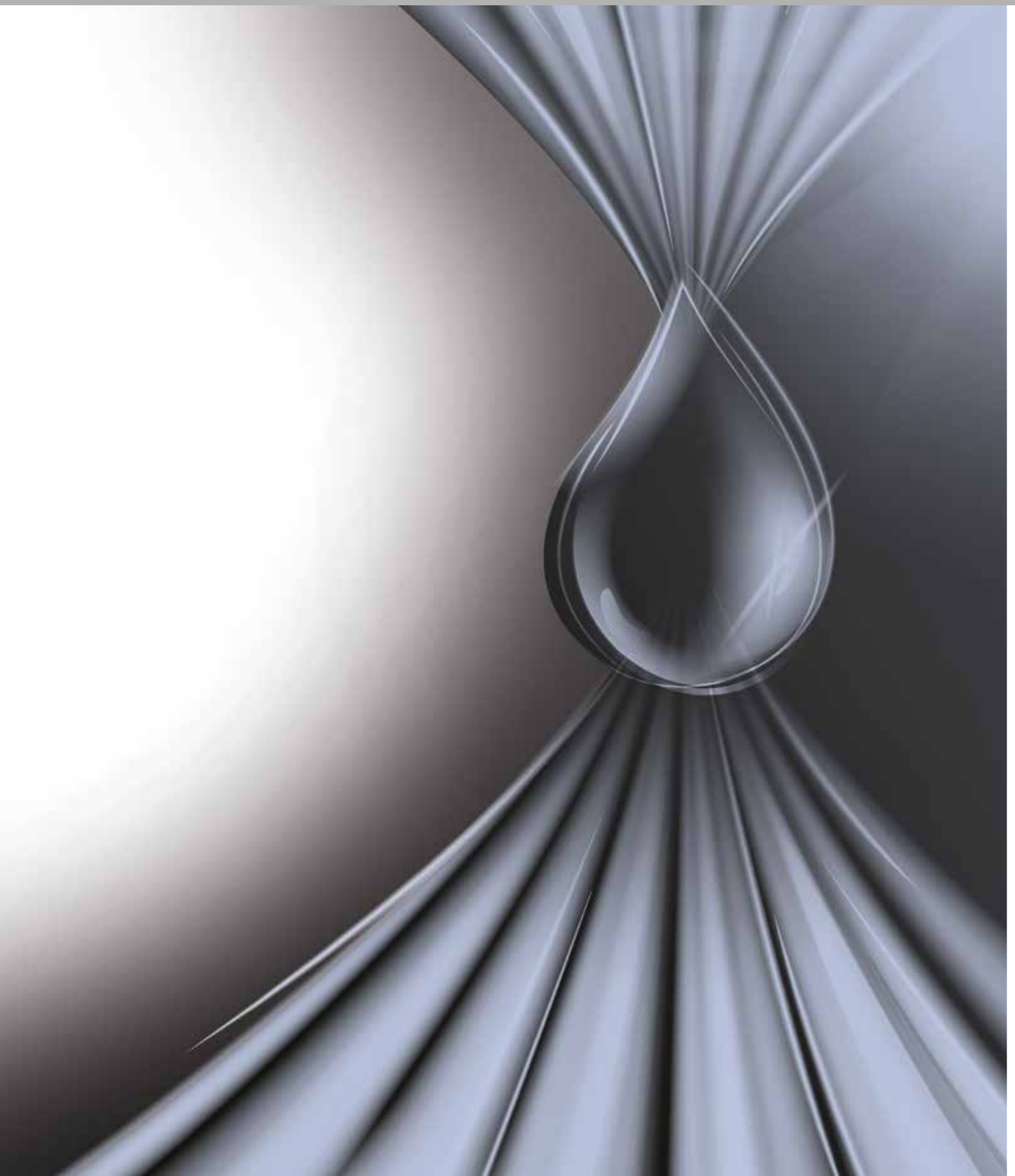
Technical Notebook

CEMENT ADDITIVES FOR VERTICAL MILLS

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CEMENT ADDITIVES FOR VERTICAL MILLS





1. MAPEI GROUP

Mapei was founded in Milan in 1937 and with more than 80 years of experience it is now the world's leading manufacturer of adhesives and ancillary products for the installation of all types of floor and wall coverings. The company also specialises in other chemical products for the building industry, from waterproofing products and special mortars and admixtures for concrete and cement, to products for the renovation of historic buildings. With its 87 subsidiaries and 81 plants in 35 different countries, today Mapei is to be considered the world's leading supplier of the most innovative products for the building industry.

1.1 ECO-SUSTAINABILITY

Mapei liquid cement additives form a system of innovative solutions for cement works; they allow a reduction of clinker while offering the same mechanical performance of cement, thus guaranteeing a reduction of 5-10% in CO₂ emissions and a saving in non-renewable raw materials.

1.2 CEMENT ADDITIVES DIVISION

Founded in 2000, C-ADD (Cement Additives Division) has grown every year in terms of turnover and volume, thanks to innovative and high-quality products combined with technical support and dedicated Research and Development. Today, supported by the group's structure and expertise, C-ADD is supplying all major cement groups worldwide, offering new technologies and local technical assistance. By combining high quality raw materials, fully computer-based production facilities and specific expertise in terms of product chemistry, industrial employment and grinding plant technology, C-ADD is able to guarantee high levels of customer assistance and product quality.

1.3 RESEARCH & DEVELOPMENT

By investing over 5% of its turnover and 12% of its Human Resources in Research and Development, the Mapei Group has become market leader in terms of innovation. The dedicated C-ADD scientists at Mapei's

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Research Centres not only develop new raw materials and grinding aid components, but are also active in customer support. In fact, Mapei's state of the art laboratories allow C-ADD to perform specific and in-depth clinker and cement analysis in order to optimise the use of cement additives and to offer customized solutions for cement performance enhancement and production improvement.

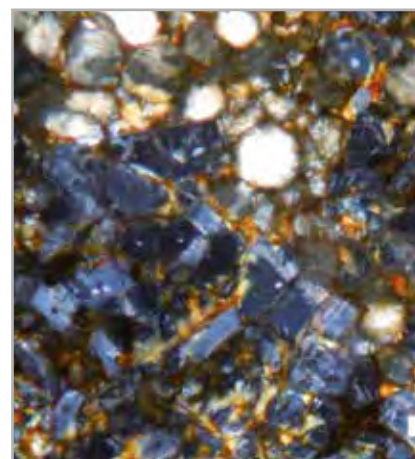
1.4 MAPEI TECHNICAL SERVICES

Process: a team of experienced process engineers from the cement industry joined C-ADD in order to provide specific technical assistance to C-ADD customers. By performing complete plant audits and by analysing the grinding circuit performance, they are able to assist C-ADD customers with the implementation of cement additives and to optimise the grinding process in all its aspects.

Analytical: The most updated instrumental analysis tools are available in our two main R&D centers in Milan - Italy and Deerfield Beach - USA, serving our customers worldwide.

- Differential scanning calorimeter (DSC)
- Differential thermal analysis (DTA) and thermogravimetric analysis (TGA)
- Particle size distribution (PSD) and Tromp Curve
- Optical microscopic analysis
- Conductive isothermal calorimeter
- Quantitative X-ray diffraction analysis (QXRD)

Our specialists are performing in-depth investigation on clinker mineral phases related to crystal size and its distribution, reduced condition, burning temperature, primary and secondary cooling rates, etc. Based on these parameters we can provide recommendations on the kiln operation conditions. We evaluate gypsum dehydration as well as sulfate balance, both in the finished cement product and in cementitious systems containing supplementary cementitious materials and chemical admixtures.



1.5 MAPEI CEMENT ACADEMY – ANNUAL CONFERENCE

Mapei is the worldwide leader in Cement Additive Technologies, deeply focused on the grinding process and cement chemistry; the VRM grinding systems are the place where process and chemistry meet together to determine the quality of the cement (mill output, vibration level, water addition, cement quality and prehydration for example). In order to serve its customers in the best possible way, Mapei has founded the Mapei Cement Academy, an annual event where 80-90 professionals from the cement industry worldwide meet to discuss about cement grinding and chemistry. This event is a highly appreciated platform to exchange information and experience between cement producers, Mapei experts and external equipment manufacturers.

2. VERTICAL MILLS - INTRODUCTION

Thanks to the necessity to improve grinding efficiency and reduce operation costs, vertical mills have made their way into the cement industry. At first, these new systems were employed for the grinding of solid combustibles and kiln-feeding raw meal. In the past decade, however, the new generation of vertical mills has demonstrated to be a competitive solution for final cement grinding as well.

The worldwide trend of rising energy costs will make the market share of vertical mills grow even further in the near future, probably becoming the main grinding system installed in new grinding installations. Considering these important developments in cement grinding technology, MAPEI has invested significant resources in R&D and technology, becoming the first company in the global Grinding Additives industry offering a completely new generation of Process Additives for vertical grinding systems: MA.G.A./VM and MA.P.E./VM.

As for tubular ball mills, vertical mills benefit significantly from the employment of specific Grinding Additives, both in terms of production increase and cement quality improvement. The effect of Grinding Additives



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is evident in all cases, especially in case of high-Blaine CEM I and blended cements (CEM II as well as CEM III, CEM IV and CEM V cement types). The different grinding processes of vertical mills compared to tubular ball mills have led to the development of a new generation of Cement Grinding Additives. These products have been specifically designed for the use in vertical mills, optimising both mill output and cement quality.

Besides high levels of energy efficiency, vertical mills have the following advantages:

- Very compact and simple installation – one single machine for grinding, separating and drying;
- Improved versatility and optimisation in a multi-product situation, thanks to a lower MRT (Material Retention Time);
- Less sensible for higher moisture-contents in raw materials, if sufficient drying energy is available;
- Lower noise level - no additional measures to reduce noise disturbances are needed.

Disadvantages are:

- Necessity to use water (up to 3%) to reduce vibrations (Specific MAPEI Grinding Additives optimise this effect, reducing the quantity of water added);
- Necessity to employ thermal sources in order to guarantee the system's temperature;
- In some cases, high-Blaine blended cements (pozzolan, fly-ash) produced in vertical mills have a relatively high water demand in the final application;
- Higher initial investments are needed if compared to traditional Ball Mills.

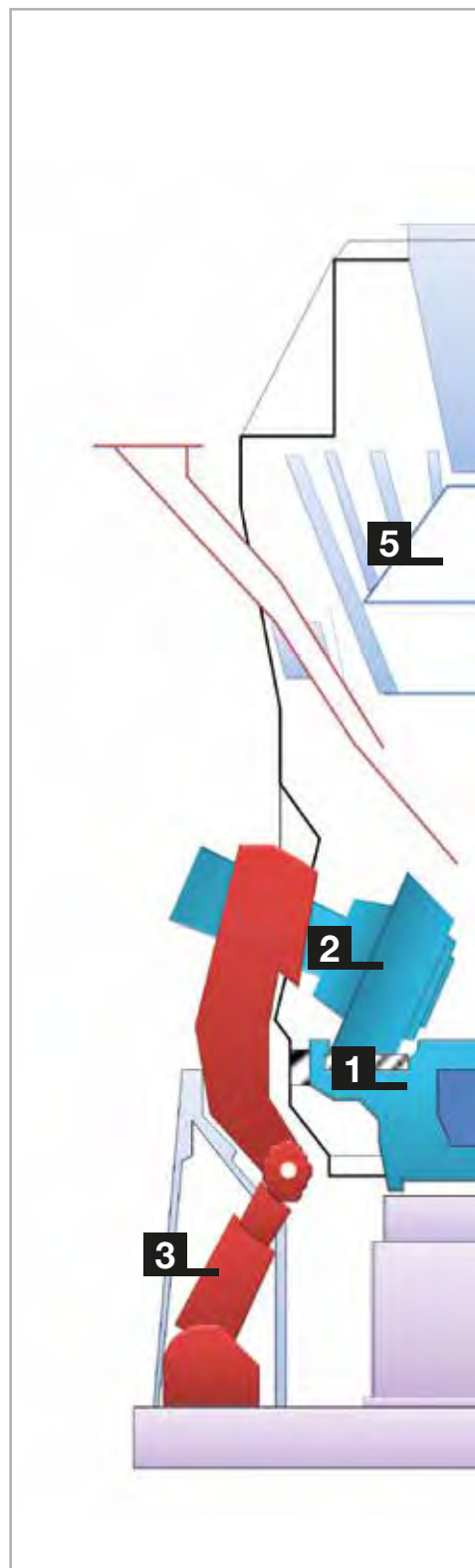
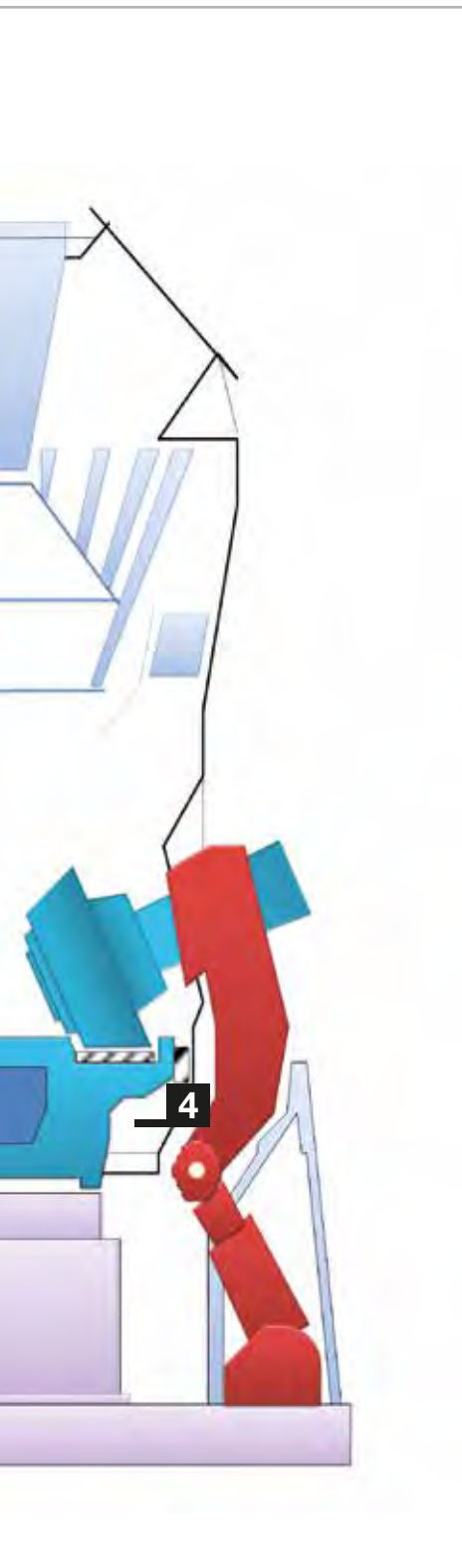


Image 1 - Vertical Mill scheme



3. PRINCIPLES OF VERTICAL GRINDING SYSTEMS

3.1 – VERTICAL MILL COMPONENTS

Image 1 shows a vertical mill and its components:

- 1** Grinding plate.
- 2** Rollers pressing the material on the grinding plate.
- 3** Pressure system of the grinding rollers.
- 4** Hot gas flow for drying the raw materials and cement temperature control.
- 5** Dynamic third generation separator.

The different manufacturers of vertical mills mainly distinguish themselves in the shape and number of grinding rollers and in the mill drive system. The dynamic separators are the same as the ones used on tubular ball mills, obviously adapted to the vertical grinding machinery.

3.2 HOW DOES A VERTICAL MILL WORK?

The raw materials are fed directly to the centre of the grinding plate, which, thanks to centrifugal forces and the pushing effect of the incoming materials themselves (both fresh and separator coarse material), are distributed evenly under the grinding rollers. The turning speed of the grinding plate, together with the pressure of the grinding rollers, create the necessary friction for grinding the materials. After being ground, the material is transported to the dynamic separator by the (more or less hot) gas flow, where the selection of the material takes place.

The gas flow, besides transporting the material, performs other important tasks:

- First material selection; the coarse particles tend to fall back on the grinding plate.
- Thermal exchange; more efficient compared to tubular ball mills, thanks to the complete mix of gases and materials.

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The coarse material coming from the separator is directed back to the centre of the grinding plate in order to be ground again.

The grinding process starts with the preparation of the so-called grinding bed, where the coarse material is crushed. Then the material is compressed and ground by the grinding rollers. For a stable grinding procedure the following parameters are important:

- The vibrations of the grinding plate.
- The ΔP of the grinding system.
- The height of the grinding bed (controlled by the dam ring on the grinding plate).
- The pressure of the grinding rollers.
- The speed of the grinding plate.

4. A NEW GENERATION OF GRINDING ADDITIVES: MA.G.A./VM AND MA.P.E./VM

The use of MAPEI's new-generation Grinding Additives, specifically developed for the use in vertical mills, allows significant increases in terms of mill output, thanks to the stabilisation of the grinding bed and the reduction of the related vibration levels. Moreover, these new generation additives can be employed in order to improve the cement's chemical-physical properties and / or to reduce water additions during the grinding operation.

4.1 MILL OUTPUT INCREASE

The products of the MA.G.A./VM series concentrate their action on compacting the grinding bed and optimising the granulometric curve of the cement by:

- Reducing the vibration levels of the grinding plate

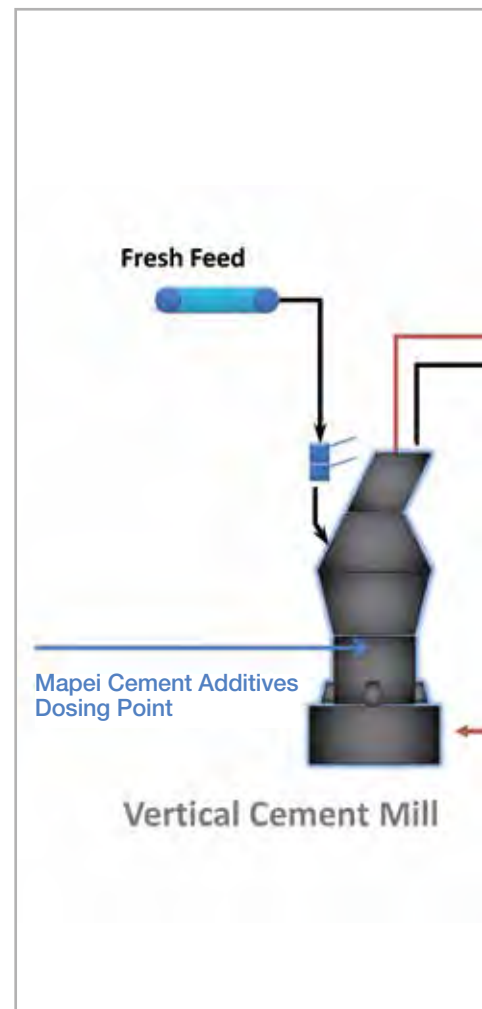
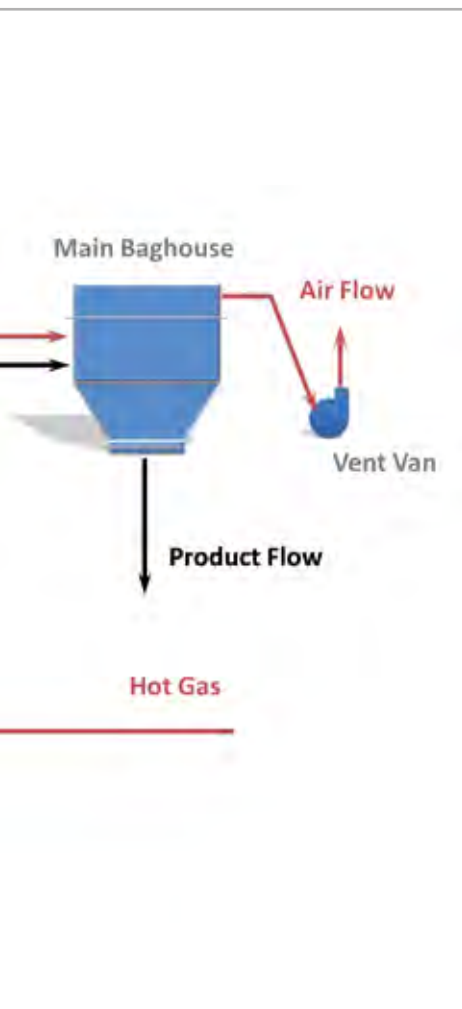


Image 2 - Vertical Grinding System





- Reducing the ΔP of the grinding system (or reduction of the circulating load)

- Optimising the thickness of the grinding bed

Generally speaking, depending on operational parameters like material properties, grinding system properties and general grinding conditions, mill output improvements between 5% and 15% can be achieved with the use of new generation products from the MA.G.A./VM series.

4.2 QUALITY AND WATER DEMAND OPTIMISATION

The use of a lower quantity of water for the reduction of vibrations makes it possible to optimise the management of the grinding system (e.g. reducing the energy costs in case a hot gas source is used). Moreover, the new generation products from the MA.P.E./VM series:

- Increase mechanical strengths at the same fineness
- Reduce the clinker content (and therefore CO₂ emissions) at the same mechanical strengths
- Reduce the water demand of the cement (a typical problem of pozzolanic and fly-ash cements, ground in vertical mills).

Note: special formulations of the MA.P.E./VM series, based on MAPEI's latest poly-acrylic technology are available in order to pre-treat cements for final concrete applications.

5. THE MAPEI DOSING LANCE

In a VRM, unlike in a ball mill, the injection point of the grinding additive, is extremely important to achieve its different purposes and to maximize benefits like output increase, strengths improvement or clinker reduction. Since many years, Mapei is leading the innovation in this field, resulting in the recent introduction of a unique Dosing Lance. This specific equipment allows in-depth optimization of the effect of Cement Additives in mill.

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In the past the VRMs were operated:

- Without grinding aids (very poor results).
- Grinding Aids dosed on the mill feed conveyor belt or inside the mill chute (poor to average results).
- Grinding Aids dosed on the grinding table through the mill water line (good results, first Mapei innovation, see for details "Facilitating cement grinding in vertical mills", ZKG International, October 2010).

The addition of Grinding Aids with the latest, state-of-the-art Mapei Dosing Lance technology allows levels of dosage / performance optimization never reached before.



The Mapei Dosing Lance is a unique device, designed and developed to ensure the most efficient dosage of Cement Additives by partially penetrating the bed of material on the grinding table and thus avoiding evaporation or loss of efficiency due to the harsh conditions inside a Vertical Roller Mill.

MAPEI GRINDING AID +
DILUTION WATER

LOW PRESSURE
COMPRESSED AIR



The Mapei Lance is a biphasic dosing system (liquid + air) designed to better disperse the Cement additives in the cement during grinding; the liquid is a mix between grinding aid and water (in the range 1:2 to 1:5) and the air is necessary to convey the liquid to the desired spot. The external part of the lance is protected by a hard plate, to ensure long life in service. Every VRM type and size requires one (or more) Mapei Lance, which will be specifically designed for each mill by our specialists. Additionally, Mapei will support and supervise the delicate phase of installation of the lances in the mill.

6. PRODUCTS

Product Group	Description	Typical Dosage	Production Increase*	Strength Increase*	Workability*	Cr(VI) reduction*	Typical Application	CO ₂ Reduction
MA.G.A./VM	Highly concentrated, high performance grinding additives, suitable for grinding all cement types in vertical mills.	100 - 400 g/t	● ● ●	● ●			All Cement Types	● ● ●
MA.P.E./VM	Grinding additives, strengths and workability (flow) improvers, specifically formulated for grinding blended cements in vertical mills (pozzolanic, blast-furnace slag, fly-ash).	500 - 2000 g/t	● ●	● ● ●	● ● ●		Blended Cements	● ● ●
MA.P.E./Cr	Specific additives for Cr(VI) reduction in vertical mills.	50 g/t/ppm				● ● ●	All Cement Types	

* at typical Dosage

● Possible ● ● Recommended ● ● ● Highly Recommended

Please contact us directly for specific product selection, assistance and technical documentation.

CEMENT ADDITIVES FOR VERTICAL MILLS

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