COMING TO YOUR AID

Emanuele Gotti, Anand Subramanian, and Davide Padovani, Mapei SpA, **outline how cement producers can optimise the dosage of grinding aids in VRMs.**

In the cement industry, the use of vertical roller mills (VRMs) for cement production is gradually becoming more commonplace due to their advantages over the more traditional ball mills.

Unlike in ball mills, the grinding process in VRMs is not carried out through the impact of steel balls, but through the compression and shearing of the material with rollers that operate at a very high pressure on a rotating table. The clinker/gypsum/SCMs mix is fed in at the centre of the rotating table and is pushed (due to centrifugal forces) to pass under the rollers, until the required fineness is reached. VRMs operate using closed circuit grinding, with the separator included in the body of the mill. The material is conveyed to the separator by a gas stream (usually air) with a suitable mass flow rate. The fine material is classified and sent to storage, while the coarse fraction falls back onto the grinding table. The material too coarse to be conveyed to the separator by gas stream can be collected and lifted to the fresh material addition point by an elevator.

The advantages of VRMs for cement production can be summarised in the following key-points:

- Production using VRMs can be significantly higher than that of traditional ball mills. In fact, VRMs can produce up to 400 tph of cement, while ball mills can on average reach a maximum production of about 180 – 200 tph.
- The specific energy consumption of VRMs (measured in kWh/t of produced material) is lower. This helps reduce the specific costs of cement production (€/kg) and, consequently, significantly reduces greenhouse gas emissions caused by the production of cement.
- While traditional mills must be first assembled by the manufacturer and then transported to the industrial site with all the resulting costs as well as logistical problems, VRMs are usually built 'on-site'.This allows mill sizes (and therefore production values) to be reached which are not achievable in the case of traditional ball mills.
- VRMs offer a greater versatility than traditional mills: for example, intermediate cleaning-silos are not necessary, as the transition times between different cement types/compositions are significantly shorter if not non-existent.
- Additionally, VRMs are less sensitive to the eventual high-humidity content of raw materials, due to the high flow of hot air streams passing through the mill body (given a sufficient energy source is present).

Figure 1. Realisation of the Mapei dosing lance for VRM.

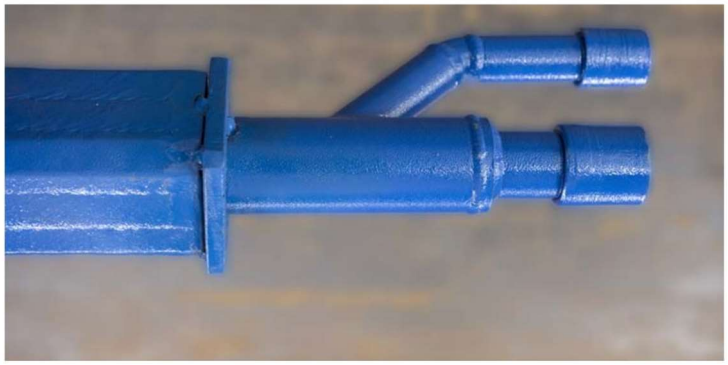

Figure 2. Details of additive/water and compressed air pipeline.

Figure 3. Spraying of cement additive on the grinding bed, close to roller.

Vibrations in vertical mills

One of the main problems when running VRMs is the onset of vibrations. These vibrations are mainly caused by irregularities of thickness and consistency in the grinding bed (composed of stones and coarse particles). If vibrations are higher than an accepted value (usually in the range of a few mm/sec. and specific for each mill) they can seriously damage the mill.

In order to reduce vibrations, in addition to some mechanical devices (e.g. the use of different roller types in the same mill, where the first roller type is used to uniform the height of the material layer, and the second roller type is used to grind), a common technique is the addition of water, normally dosed on the material to be ground directly on the rotating table of the mill. This is a very effective

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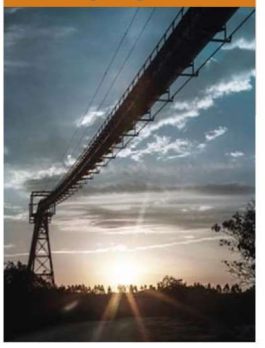

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way to reduce vibrations, but it must be carefully controlled in order to avoid any detrimental effects on cement quality. In fact, if not properly dried out after grinding, water reacts with cement, promoting some changes in chemical structure, such as 'pre-hydration' of cement and/or modification of gypsum dehydration, reducing global performance.[1] In order to avoid this problem, the volume of water added should be as low as possible and not beyond the range 0.5 – 1.5% with respect to material mass.

Reduction of vibrations through the addition of grinding aids

A very effective way to reduce the amount of water needed is the use of specific chemical grinding aids to tackle vibrations. The effectiveness of these additives depends on several aspects such as their chemical composition, their dilution and the point of insertion.

The grinding aids used for traditional ball mills are often less efficient in a VRM. This is likely due to the significantly stronger ventilation in VRMs than in ball mills which could promote the early evaporation of the grinding aid. This effect is more evident when the grinding aid is introduced in a standard insertion point, such as on the raw materials conveyor belt. In this case, a stripping phenomenon physically eliminates a significant amount of the grinding aid before it can express its efficacy during the grinding process itself.

For these reasons, Mapei Cement Additives Division developed a class of grinding aids, called VM, specifically formulated for use in VRMs and suggested a specific way to add these process additives during VRM operation. The main features of this technology[2] can be briefly summarised as follows:

- Thanks to the low volatility of the ingredients used, these grinding aids are not impacted by the high ventilation present in a VRM and remain unchanged until they take part in the grinding process, remaining unaffected by the specific chemical activation of the main components and their effect on the compressive strength and cement fineness.
- The dosing point of the chemical additive in a VRM is crucial: the addition on the grinding bed, for example together with the water already used or with a dedicated pipeline, allows for improvements in efficacy and a significant reduction in vibration levels.

Dilution of grinding aids at the moment of use is also important in order to improve the dispersion of the active components and to optimise the contact between additive and cement surface. In fact, additives are often used at a very low

Table 1. Outlines of the industrial tests.

Dosing system	1) No additive	2) On the table, existing pipe	3) Mapei Dosing Lance
Additive name	-	MAGA/VM 336 ACS	MAGA/VM 336 ACS
Additive dosage	-	300 g/t	300 g/t
Additive dilution ratio	-	Pure additive	1:3 (additive/water)
Average chemical-physical characteristics of cements			
Limestone (%)	12	12	12
SO_3 (%)	2.3	2.3	2.3
Residue, 45 micron (%)	5.4	5.1	4.6
Blaine (cm_2/g)	3930	3960	4010
Average production parameters of the VRM			
Mill output (tph)	183	197	204
Water addition (%)	3.6	2.9	2.5
Average peak zone spikes (mm/sec.)	8.4	6.6	5.0
Average performance of cements			
Strength, 2 days (MPa)	23.2	25.1	27.3
Strength, 28 days (MPa)	47.1	51.8	54.4

dosage (0.015 – 0.025% of cement mass) and are not always able to express their potential because of the difficulty of dispersion on the solid material. In other words, it often happens that the additive meets only a part of material entering the mill. With a better dispersion, an appropriate dilution of additive can increase production, reduce the additive amount needed and maintain or even improve the quality of cement. Ensuring the correct dilution of cement additives in the ball mill has been a focus for grinding specialists and detailed publications have been released by Mapei engineers.[3] The same concept can be successfully applied to VRMs, using a suitable and specifically designed dosing system, as described in this article.

Maximising the positive effects of cement additives

Taking into account the considerations reported here, Mapei has moved forward in the development of innovative systems which can maximise the positive effects of cement additives, in particular for VRMs.

In this article, a proprietary technology (Mapei Dosing Lance for vertical mills) is described. It consists primarily of a biphasic lance (liquid/air) composed of coaxial tubes, protected by a wear-resistant plate, flanged and installed inside the VRMs.

With this technology, the grinding aid is introduced in the pipeline of water used to reduce vibrations. At the same time, the lance dilutes the concentrated additive and doses it in the right place on the grinding bed with optimum dispersion due to the air pressure that appropriately directs the liquid. Moreover, in order to optimise the efficacy, any lance is tailored to each specific mill, depending on factors such as type and size of mill, number of rollers, presence of other lances for anti-vibration water dosing, and type of cement produced.

A more detailed description of this technology is given in Figure 4, which represents an orthographic projection showing the side, top and front view of the nozzle, and Figure 5, which shows the position of the nozzle inside the VRM.

Figures 1 and 2 show a practical realisation of the dosing lance, while in Figure 3 it can be seen in action, when the blend additive/water is sprayed on the grinding bed.

Put to the test

In Table 1 the results of an industrial test to produce a limestone Portland cement

(CEM II/A-LL 42,5 R) are reported. The test has been performed with a high concentrated grinding aid and quality improver for early and late strengths. During the test the fineness of cement has been maintained at around 4000 cm^2/g. The main process parameters of the VRM (six rollers, 5.3 m diameter) have been collected in three different configurations: 1) without the addition of the grinding aid, 2) with the addition of the grinding aid with a traditional dosing system, and 3) with addition of the grinding aid with the Mapei Dosing Lance. All data presented refers to an average production of two days for each configuration. Finally, compressive strength on standard mortar has been performed on the cements produced during the test.

The results show that the use of Mapei Dosing Lance can allow water additions to be reduced when compared to production without the use of grinding aids, and also when compared to production using a traditional grinding aid dosing system. Despite the reduction of water, mill vibrations can still be significantly reduced, confirming the ability of the system to stabilise the grinding bed.

Moreover, the stability of the mill and the better dispersion of the grinding aid has been seen to increase the output of the mill.

Finally, the strength of the resulting cement has been largely improved, indicating that, with the same dosage of grinding aid, the Mapei Dosing Lance promotes its dispersion and consequently its efficacy in enhancing performance.

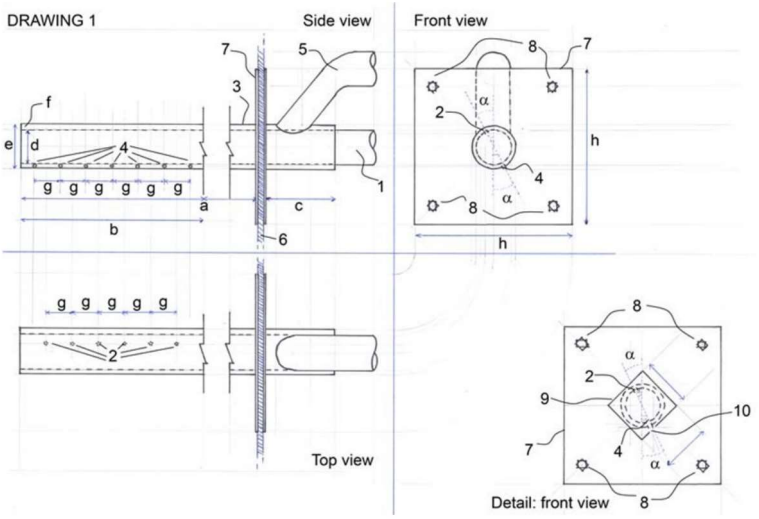

Figure 4. 1) additive/water pipeline, 2) external holes, 3) external pipeline, 4) internal holes, 5) air pipeline, 6) wall of mill, 7) fixing plate, 8) screw threads, 9) square cross section shield, 10) external holes.

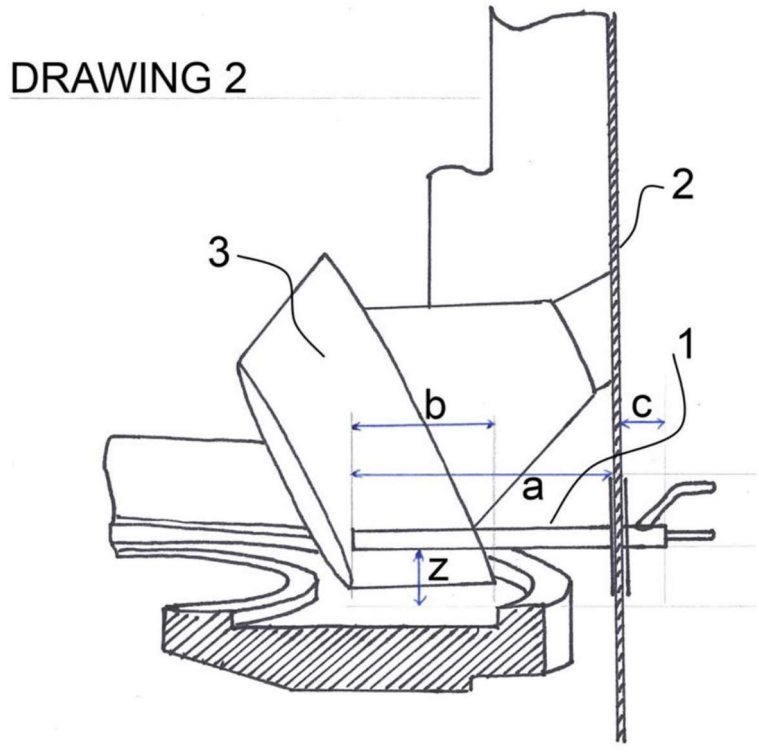

Figure 5. 1) dosing lance, 2) wall of the mill, 3) roller.

Conclusion

The Mapei Dosing Lance is designed to help to optimise the dosage of grinding aids in VRMs to produce cement.

Its design prevents any loss of grinding aid caused by the stripping phenomenon inside the mill and improves its dispersion on the grinding bed.

The main benefits of the technology include the reduced need to add water to the mill, the reduction of vibrations, the increase of mill output, the saving of grinding aid, a reduction in the specific cost of production and the enhancement of cement performance.

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