VRMs: add stability, not water

While most vertical roller mill producers want to avoid injecting water onto the mill table, the need to achieve a target production level and product fineness makes this a regular practice. Grinding aids can help to avoid high levels of water injection.

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In recent decades the cement industry, particularly in developing Asia-Pacific countries, has increasingly adopted the use of vertical roller mills (VRMs) for finished cement grinding. This is mainly due to flexibility, lower energy consumption and lower noise compared to conventional ball mills. In most, if not all cases, water injection is used to reduce mill vibrations and maintain grinding bed stability. Most VRM manufacturers want to avoid injecting water on the table. However, the desire to achieve a target production level and product fineness makes water injection inevitable. It is generally not recommended to add water to a hydraulic binder before its final application. This premature addition of water induces cement prehydration that often results in extended setting time and lower strength development.[1]

To offset the negative impact of prehydration from table water injection, cement plants often resort to grinding the cement finer, creating a negative self-perpetuating cycle. Grinding finer requires a higher grinding pressure, leading to mill vibration and a requirement for table water injection. Therefore, it is not always possible to recoup all of the lost performance. The retardation issues are commonly offset with lowered SO_3 targets through lower sulphate addition. This further jeopardises the cement quality, reactivity and rate of hydration.

The material's short residence time on the table creates frequent small disturbances to which VRMs respond rapidly. Hence, spraying water on the table is a widely-accepted practice to maintain consistent material bed on the table.

"It is generally not recommended to add water to a hydraulic binder before its final application."

The use of VRMs can lead to the injection of water to achieve target production rates and product fineness

Water comes either free or at a very low cost to most plants and hence its use is widely accepted. However, with regards to sustainability, 40 per cent of the world's population will live in severe water shortage by 2050.

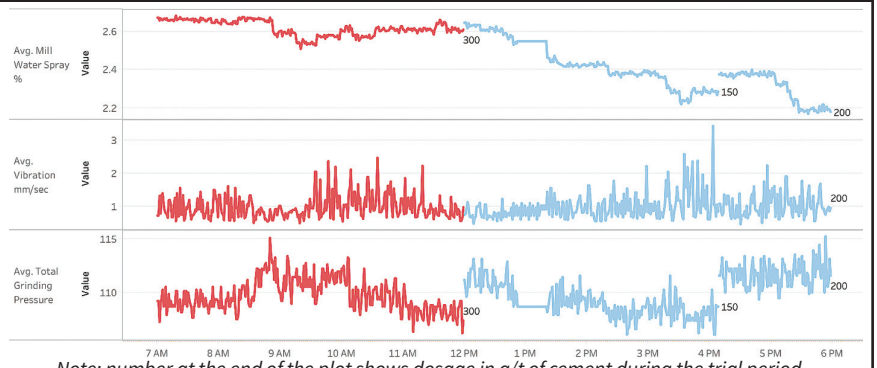
Generally, when the raw materials' moisture is high, the table water injection is less, since the wet material brings in bed stability. Therefore, grinding ordinary Portland cement with a lower fineness has a higher table water injection than blended cement with higher fineness, mainly due to the clinker substitution materials' high moisture.

The optimal method of grinding cement in a VRM should be to achieve the lowest specific power consumption, highest possible mill output, lowest mill vibrations with lowest possible grinding pressure and the best cement quality in terms of setting time and strength. Mill operators rightly err on the side of caution, since the mill's vibration often gets higher with even a small reduction in water injection.

GCP's TAVERO® VM Technology

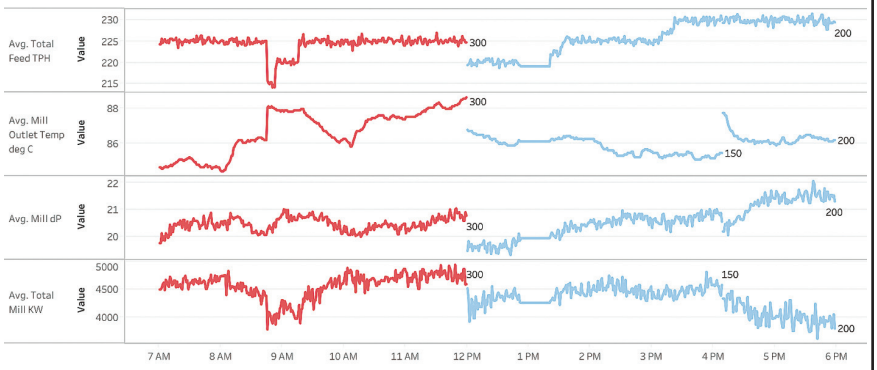
GCP Applied Technologies' TAVERO® VM cement additives combine the use of new and existing technologies formulated specifically to the unique characteristics of the VRM. This helps them to mitigate many of the process, operational and quality

Figure 1: key mill operating parameters, using GCP QI 001 (red) and TAVERO® VM EXP 002 (light blue)



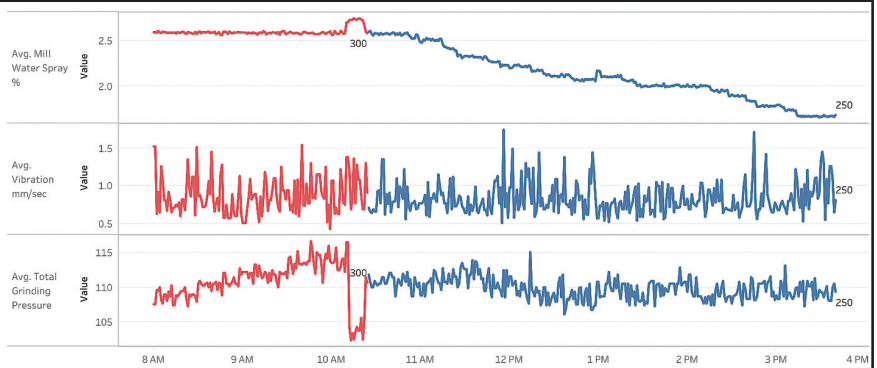
Note: number at the end of the plot shows dosage in g/t of cement during the trial period

Figure 2: key mill operating parameters, using GCP QI 001 (red) and TAVERO® VM EXP 002 (light blue)



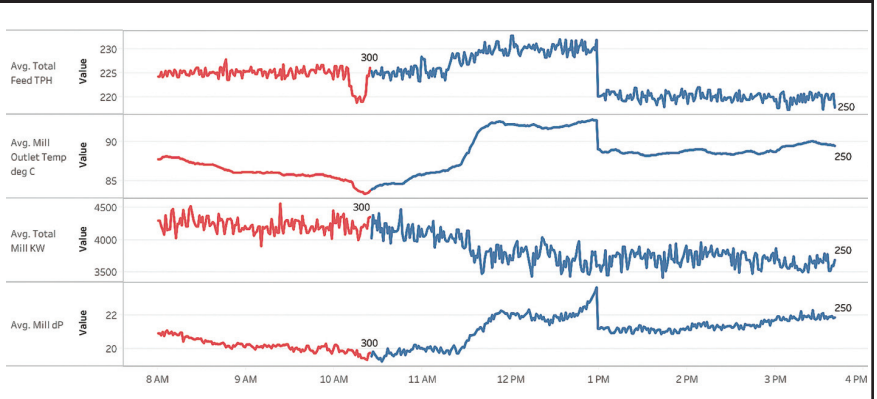
Note: number at the end of the plot shows dosage in g/t of cement during the trial period

Figure 3: key mill operating parameters, using GCP QI 001 (red) and TAVERO® VM EXP 003 (dark blue)



Note: number at the end of the plot shows dosage in g/t of cement during the trial period

Figure 4: key mill operating parameters, using GCP QI 001 (red) and TAVERO® VM EXP 003 (dark blue)



Note: number at the end of the plot shows dosage in g/t of cement during the trial period

issues and allows the VRM to work in a stable fashion with very little additional water. Compared with no additive use, TAVERO VM products help keep the table water injection as low as reasonably practical while:

- maintaining similar levels of bed stability and mill vibrations
- allowing an increase in mill output
- lowering mill-specific power consumption
- improving cement quality by lowering setting time and improving strengths.

TAVERO VM allows for reduced water and sustained mill vibrations in addition to normal grinding aid benefits. In addition, GCP personnel aid in the optimisation of the process by calling on over 50 years' experience in global VRM operation.

Recent field trials

It would be difficult to assess the effect of this technology through laboratory-scale studies alone. A pre-trial survey will enable GCP to assess the potential of any VRM to benefit from the TAVERO VM approach, which will then give a far higher potential of success to any subsequent field trial. In southeast Asia, GCP recently conducted two field trials applying TAVERO VM – one grinding a PCC cement in Indonesia and the other grinding a blended cement (PCB) in Vietnam.

Case 1: Java, Indonesia

This case involved grinding PCC-type blended cement in Indonesia. The cement is ground to a fineness of 4700cm^2/g, R 45µm <4 per cent with the baseline condition using a traditional cement additive "GCP QI 001" at a dosage of 300g/t of cement. The mill operations and key process parameters are compared with two different TAVERO VM products of varying capacity to reduce table water injection. The scale of water injection possible with the two different products and the benefits are illustrated in Figure 1. Samples are collected for each baseline condition and also during the trials with TAVERO VM at different water injection levels.

Figure 1 illustrates the extent of water reduction possible, keeping the mill vibrations in check and a similar grinding pressure. Increasing the dosage of the TAVERO VM EXP 002 product from 150 to 200g/t enables further water injection reduction at similar mill vibrations. The trends indicate stable mill operation even with a significant reduction (15 per cent) in water injection, including a modest

increase of ~5 per cent in mill output.

Figures 2 and 4 illustrate the principle behind GCP's TAVERO VM. This additive easily tackles the biggest challenge of reducing the water injection at similar fineness, mill vibration, mill exit temperatures and grinding pressure. Water injection reduction is defined by the ability to sustain both the mill vibration and the mill exit temperature at levels similar to the baseline. Note the small and similar bandwidth in mill outlet temperature and mill vibration, thanks to TAVERO VM products.

Figure 3 shows that TAVERO VM EXP 003 gives a higher capability to reduce water while maintaining similar vibration and production. This product significantly reduces water injection by 40 per cent from 2.7 per cent (6m^3/h) to 1.6 per cent (3.6m^3/h) at a dosage of 250g/t of cement, without losing mill and process stability.

As the water injection decreases, there is a drop in cement prehydration measured through TGA, as noted in Figure 5. Product EXP 003 accelerates to the scale of 25-45min in both initial set time (IST)and final set time (FST) of the cement samples compared with the reference cement (GCP QI 001). This magnitude of acceleration is generally considered a significant acceleration in cement quality terms.

Similarly, there is a good correlation in the strength increase in all ages with respect to the decrease in the cement pre-hydration, resulting from reduced water injection. Both of the TAVERO VM products are able to enhance strength consistently by ~2MPa. Setting acceleration and strength enhancement are a boon for cement quality, since the plant can derive other direct benefits (an ability to use more SCMs that allow a reduction of CO_2 emissions per tonne of cement, and an ability to reduce fineness while still being able to achieve quality compliance) and indirect benefits (matching fresh concrete properties, reaching hardened

Figure 5: prehydration vs water injection and cement setting time – GCP QI 001 (red), TAVERO® VM EXP 002 (light blue) and TAVERO® VM EXP 003 (dark blue)

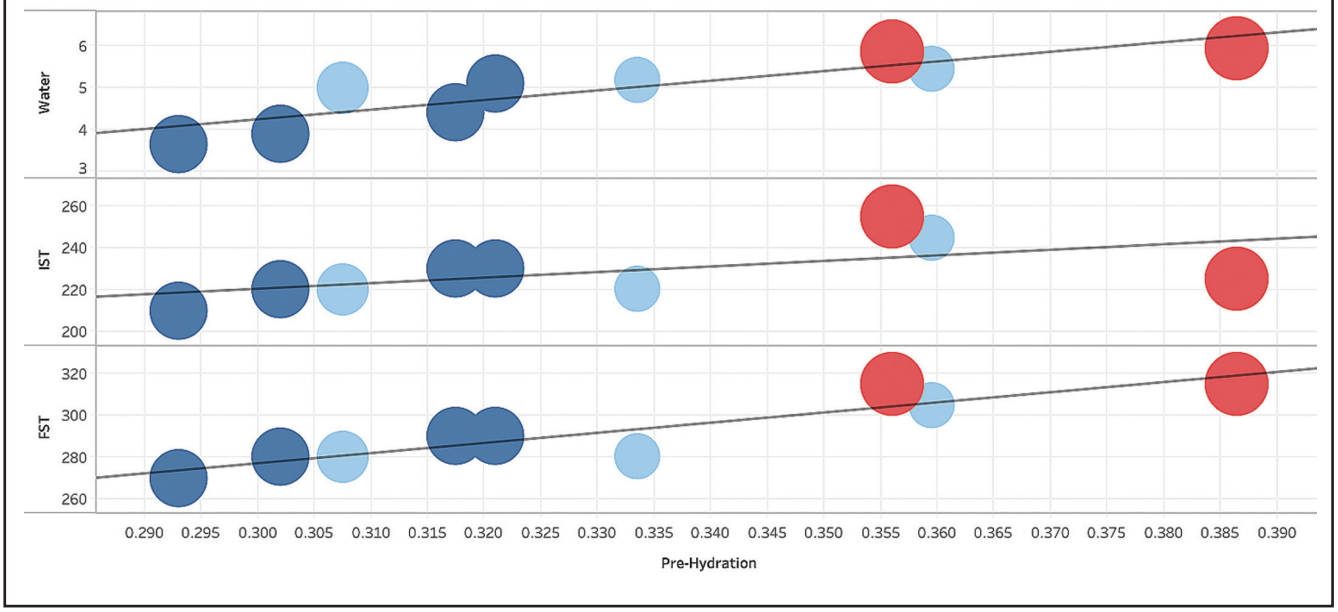
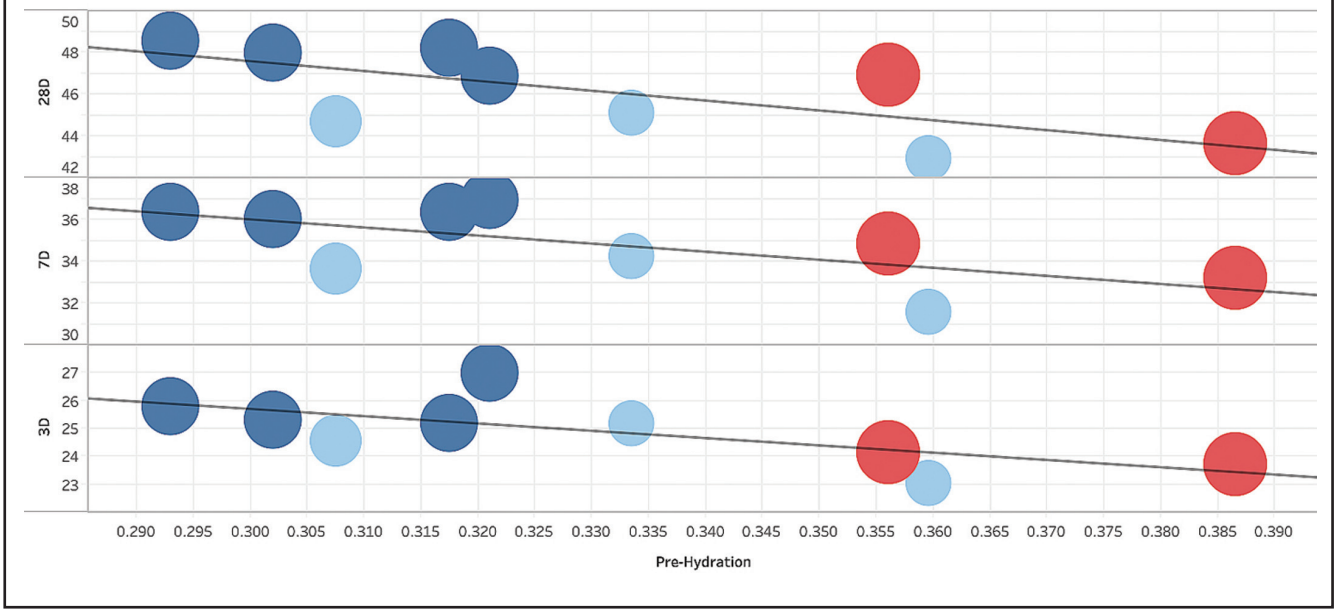


Figure 6: prehydration vs compressive strength – GCP QI 001 (red), TAVERO® VM EXP 002 (light blue) and TAVERO® VM EXP 003 (dark blue)



concrete properties, optimised dosage of admixtures and better admixture compatibility in concrete) from these.

Case 2: VRM in south Vietnam

This case is about grinding blended PCB-type cement in a VRM in Vietnam. The cement is ground to a fineness with a specific surface area (SSA) of 4000cm²/g, R45µm <3 per cent with the baseline condition using no cement additive. TAVERO VM is applied in two ways:

1. with the same cement recipe
2. with a different recipe by reducing clinker in the cement.

The water addition level needed to maintain stable VRM operations without any additive is in the range of 3.2-3.3 per cent. When the TAVERO VM additive is used, the water injection reduced to as low as 1.4 per cent – water is more than halved when compared with the baseline while maintaining similar vibration levels (see Figure 7). The product enhances production by ~15-20tph from the baseline (see Figure 8). Acceleration to the scale of 10-35min in IST and 20-50min in FST is observed (Figure 9). Furthermore, an average of ~15 per cent strength increase in all ages from the blank cement having the same recipe is achieved (see Figure 10). In the cement with seven per cent clinker reduction, the strength is sustained. In summary, in the south Vietnam plant example TAVERO VM was able to increase production by 15-20tph, accelerate setting time by 10-35min and increase strengths at all ages by 15 per cent.

Add stability, not water

It is evident from both case studies that TAVERO VM grinding aids can offer significant reductions in water consumed for table stabilisation and bring measurable improvements in quality over and above those possible from traditional quality improvers, while as a minimum, maintaining other process parameters such as mill output and specific power consumption. There are many and varied VRM systems in the marketplace. The TAVERO VM range of grinding aids calls on the experience of over 150 field trials globally and, as such, the TAVERO VM approach offers a unique market advantage to cement producers. ■

Figure 7: key mill operating parameters – blank with 86 per cent clinker (red), TAVERO® VM EXP 100 with 86 per cent clinker (light blue) and TAVERO® VM EXP 100 with 79 per cent clinker (dark blue)

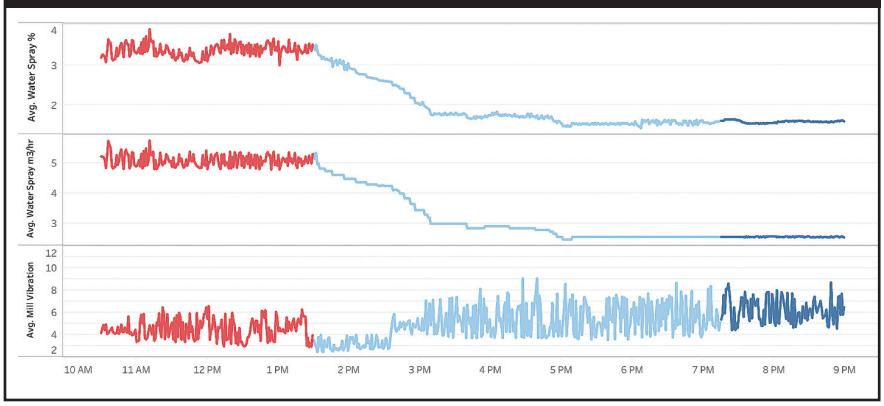


Figure 8: key mill operating parameters – blank with 86 per cent clinker (red), TAVERO® VM EXP 100 with 86 per cent clinker (light blue) and TAVERO® VM EXP 100 with 79 per cent clinker (dark blue)

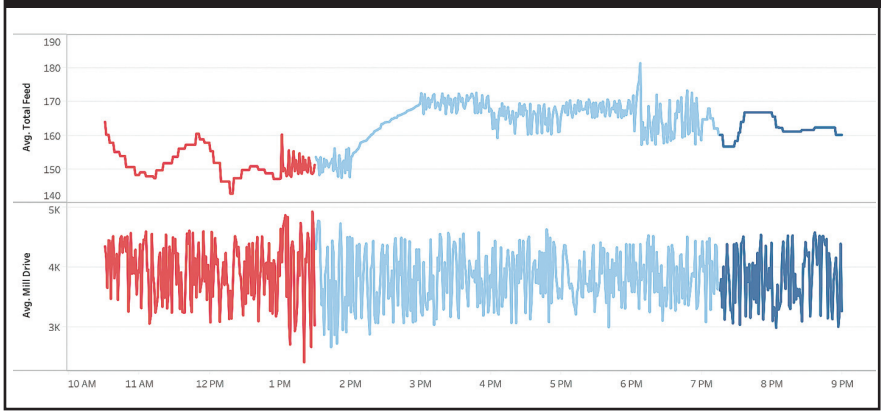


Figure 9: key mill operating parameters – blank with 86 per cent clinker (red), TAVERO® VM EXP 100 with 86 per cent clinker (light blue) and TAVERO® VM EXP 100 with 79 per cent clinker (dark blue)

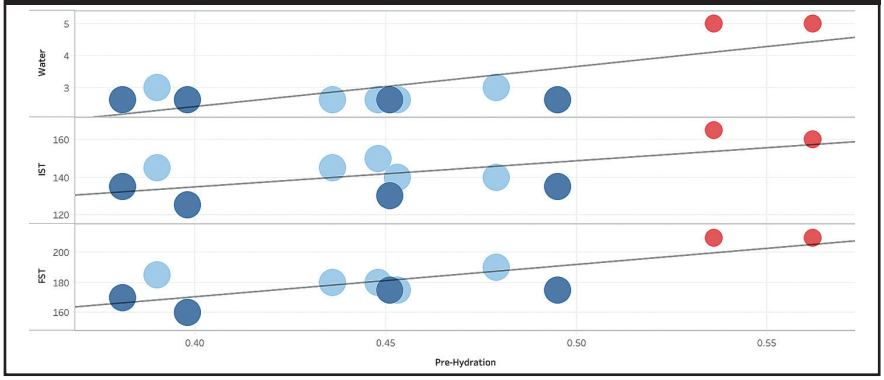
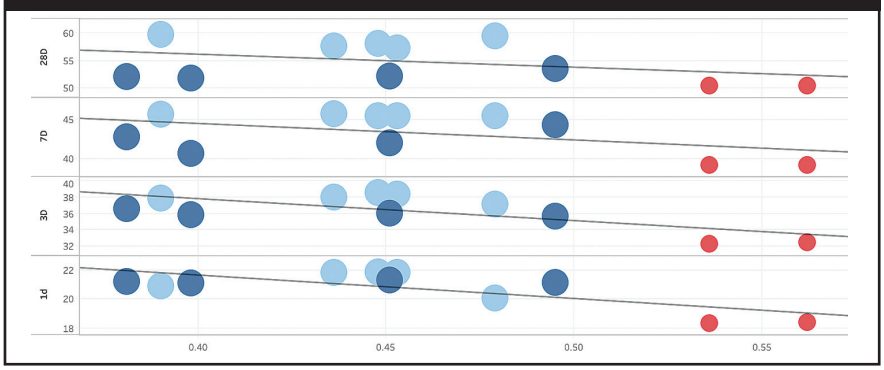


Figure 10: prehydration vs cement compressive strength – blank with 86 per cent clinker (red), TAVERO® VM EXP 100 with 86 per cent clinker (light blue) and TAVERO® VM EXP 100 with 79 per cent clinker (dark blue)



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[1] MARSAY, K, GIBSON, L AND CHEUNG, J (2017) 'VRM optimisation' in: *ICR*, August, p56-60.