Making VRM cement production greener

With water stress a particular concern of climate change, vertical roller mills (VRMs) consume a considerable amount of water to stabilise the grinding bed against excessive vibrations. A key enabler of lowering water spray is the use of an appropriate grinding aid product designed for use in VRMs. Using two cement industry case studies, GCP explains how its grinding aid products for VRMs can save water, fuel and CO_2.

■ *by **Keith Marsay**, **Jeffrey Thomas** and **Riccardo Stoppa**, GCP, USA*

Climate change is an increasingly important topic for the cement industry, and while the primary focus is to reduce the CO_2 emissions from cement manufacture, it is important to realise that even with the most optimistic projections, climate change will affect the industry in many ways.

For example, increasing global temperatures, coupled with reduced or less reliable rainfall, are projected to increase water stress to dangerous levels in many regions of the world. The potential severity of this issue is illustrated by the map in Figure 1, which shows that in less than 20 years we can expect vast areas of the earth to experience a high or very high degree of water stress, which is defined to occur when the demand for water exceeds the available supply during at least part of the year.

Within the cement industry, there has been a notable increase in the use of vertical roller mills (VRMs) for grinding cement, with demand for new VRMs now significantly outpacing demand for ball mills.[2] This is a positive trend overall, as VRMs consume approximately 35 per cent less energy than ball mills for finish grinding.[3]

One drawback of VRMs is that they consume a considerable amount of water for the purpose of stabilising the grinding bed against excessive vibrations. Water usage for a VRM can range from as little as $1m^3/h$ for a well-optimised smaller mill up to in excess of $10m^3/h$ for a large mill under commissioning. A typical VRM that is spraying $3m^3/h$ of water onto the grinding bed would consume $36m^3$ (36t) of fresh water during one 12h shift, equivalent to the daily household water consumption of

Figure 1: map showing regions of the world projected to have high levels of water stress by 2040 from the World Resources Institute [1]

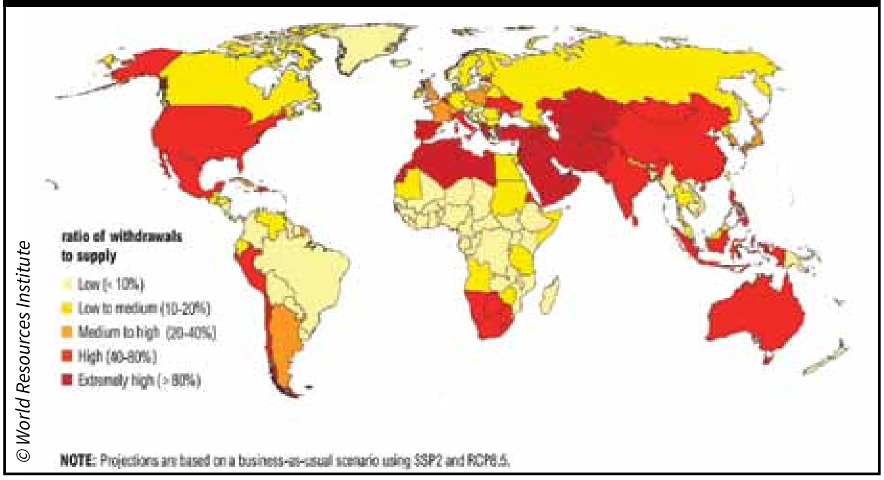

Table 1: summary of the VRM operational improvements from case study 1

Mill	Output (tph)	Water consumption (lph)	Fuel consumption (lph)	CO_2 emissions (kg/t)
Baseline	139	1000	54	720
With TAVERO® VM	143	600	46	704
Change (%)	+3	-40	-15	-2

anywhere from 75-800 people depending on the region.[4] Naturally, the higher the water stress in the region where the VRM is located, the more impactful the water consumption would be.

The impact of VRM water spraying goes beyond the direct consumption of fresh water. If the mill is grinding cool clinker (for example, at a standalone grinding station) it is then a requirement to heat the mill using fossil fuels to maintain an adequate milling temperature. The amount of fuel needed to heat a VRM is increased significantly when water is sprayed on the bed, due to the large amount of evaporative cooling that occurs as the water vaporises inside the mill. Thus, a reduction in water spray can result in fuel savings as well as water savings.

A further consideration is the negative effect of VRM water spray on cement quality. High levels of water spray cause prehydration of the cement, which can reduce strength, extend set times and interfere with the effect of chemical additives and admixtures.[5-8] Therefore, in some VRMs there can be a triple negative of high water consumption, excess fossil fuel consumption and lower cement quality.

Fortunately, all of these issues can be

At the cement plant in southern Africa, the reduced prehydration and the chemical action of the TAVERO VM additive facilitated the replacement of two per cent of the clinker with limestone

addressed through the use of chemical additives that help to stabilise the mill, reducing the need for water spray. For example, GCP offers the TAVERO® VM range of cement additives specifically designed for use in VRMs. Use of a TAVERO VM product in conjunction with GCP's process experience can significantly reduce the quantity of water required to stabilise the VRM grinding bed. This in turn reduces the amount of fossil fuels required to heat the mill and improves cement quality by reducing the negative impact of cement prehydration.

Below GCP presents two cement industry case studies from VRM systems located within the zones of high water stress shown in Figure 1.

Case study 1: southern Africa

A customer operating a VRM grinding station in southern Africa needed to improve cement quality to facilitate clinker reduction. The mill had been in operation for several years and water usage for bed stabilisation was at less than one per cent of cement production, which could be considered a lower than average value. As the clinker entering the mill was cool, the mill was heated with fuel oil to ensure that the water could be evaporated and the mill operated at a reasonable outlet temperature.

At the time GCP conducted a field trial. The baseline conditions, using a competitor grinding aid, were: 139tph mill output, 1m^3/h of water spray and 54lph of fuel oil. The degree of prehydration of the cement made under these conditions, as measured by thermogravimetric analysis (TGA) in a GCP laboratory, was Wk = 0.22 per cent. This is a lower than average prehydration value,[3] so this VRM was by no means being mismanaged.

With the application of the TAVERO VM grinding aid product and the process experience of the GCP field technical engineers, it was possible to lower the water spray required for bed stabilisation to 0.6m^3/h, a reduction of 40 per cent (see Table 1). This also resulted in a 15 per cent decrease in fuel oil consumption to 46lph and a modest improvement in mill output to 143tph (a three per cent increase). The prehydration value of the finished cement decreased to less than Wk = 0.18 per cent, a very low value for a VRM cement. This particular grinding station was running around 100h/week at the time of the trial, so this represents weekly savings of 40m^3 of water and 800l of fuel oil. This may sound like a relatively modest quantity of water, however, it is worth noting that household water consumption per capita in Africa is low by worldwide standards at about 20-40l per day.[9] Therefore, the savings from this field trial correspond to the personal water consumption of around 150-300 people, which in a water-stressed region is not insignificant.

The improvement in cement performance resulting from the reduced prehydration and the chemical action of the TAVERO VM additive facilitated the replacement of two per cent of the clinker with limestone, generating both cost and CO_2 savings for the customer.

Case study 2: southern Europe

The next example relates to a VRM operating at an integrated cement plant in southern Europe.

In this case there was no need for fossil fuel to heat the mill as the clinker entering the mill was hot and additional heating needed to maintain the mill operating temperature was available from the clinker cooler. Although this mill had been operating for over 10 years, the water spray onto the grinding bed was relatively high, at about 2.5 per cent of fresh feed, which represented in excess of 500m^3 of water consumption per week. The customer contacted GCP for a field trial, with the primary goal of improving cement quality to facilitate clinker reduction.

During the course of the field trial, the use of a strong TAVERO VM quality improver enabled the water spray to be reduced by 40 per cent to about 1.5 per cent of fresh feed. This represented a significant water saving of about 200m^3/week. Further reduction in water spray was limited not by mill vibrations but by the need to prevent the mill outlet temperature from becoming too high. When this happens, there are other steps that can be undertaken by the mill operator to allow further water reduction, such as additional cooling of the clinker before it enters the mill.

Table 2: summary of VRM operational improvements from case study 2

Mill	Output (tph)	Water consumption (lph)	CO_2 emissions (kg/t)
Baseline	200	4,800	576
With TAVERO® VM	210	2,700	531
Change (%)	+5	-44	-8


The cement plant in southern Europe replaced an additional seven per cent of the clinker with limestone decreasing cement-related CO_2 emissions by eight per cent

In the present case, the increase in cement quality that resulted from the reduced water spray, along with the chemical action of the TAVERO VM additive, allowed the customer to replace an additional seven per cent of the clinker with limestone while maintaining the same strengths. This clinker reduction decreased the CO_2 emissions associated with the cement by eight per cent (see Table 2).

Final thoughts

GCP field technical engineers have conducted hundreds of VRM field trials over the past ~20 years, resulting in some general observations about the use of VRMs to grind cement. While water spray onto the grinding bed is almost always necessary to stabilise the mill and ensure continuous, reliable operation, the amount of water spray is often greater than is necessary. As discussed in this article, this means that there is often an opportunity to reduce fresh water and fuel usage while improving the quality of the cement. With the increased urgency to reduce CO_2 emissions from cement manufacture, it is imperative, both from an economic and environmental perspective, that cement quality be maximised to allow as much clinker substitution as possible.

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A key enabler of lowering water spray is the use of an appropriate grinding aid product designed for use in VRMs. GCP's experience from the field has shown that different VRM models and designs each have their own unique characteristics that should be taken into account. The TAVERO VM range of additives are suitable for all mill systems. GCP's knowledge and experience enables it to customise the product to suit both the cement being produced and the mill design it is being produced on.

In many cases, small changes to the mill operation based on GCP's global experience result in meaningful improvements to both mill efficiency and cement quality, delivering results that are over and above what just a quality-improving chemical can deliver. ■

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