
Picture: Loesche GmbH, Germany

CEMENT
SikaGrind®
FOR VERTICAL ROLLER MILLS

BUILDING TRUST

SikaGrind®
FOR VERTICAL ROLLER MILLS

Concrete is an essential element for innovation in construction. The continuous development, since more than 150 years, made concrete to be the most important construction material at all.

The cement industry contributed a significant share to the progress of the concrete technology:

- Good and long lasting workability
- Adaption to different ambient temperatures (summer/winter)
- Pumpability, long distance and/or high elevation, no separation
- Fast strength development, high early strength
- Durability

In addition to rising technical demands, the cement industry is continuously improving the ecological footprint. The production of clinker is still an unavoidable source of CO_2-emissions. New clinker types with lower burning temperature and/or less calcium carbonate are in the pipeline respectively being used already. Nevertheless, in the past decade, the main measures to improve the sustainability have been the use of alternative fuels and the reduction of the clinker factor through the use of secondary cementitious materials (granulated blast furnace slag, fly ash, pozzolanes, limestone etc.).

ELECTRICAL ENERGY

The grinding of the finished cement consumes approximately one third of the total electrical energy of a cement plant. Vertical Roller Mills (VRM) have a clearly higher energy efficiency than ball mills, even if the ball mill is combined with a roller press. This and further arguments led to the increased share of VRM for the grinding of finished cement. Taking into account that VRM usually have a bigger output than ball mills, it can be declared that the major part of the cement production with newly installed mills comes from VRM.

The grinding of raw material and especially the challenging slag grinding is since many years almost completely in the hands of VRM.

In a ball mill, the particles are ground by repeated impact forces. The material needs usually more than 20 minutes from mill entrance to outlet, uncountable impacts take place on this way. Depending on the efficiency of the separator and the Grinding Aid, agglomerates of fine particles are rejected and pass the ball mill again. Repeated impact and attrition cause a certain proportion of very fine particles and a broad particle distribution. Expressed as inclination of the particle size distribution according RRSB, cements from ball mills generally have a rather low slope [n'].

In a VRM the grinding takes place by pressure and shear force. The clinker passes within seconds between roller and table. The energy input to the material during one passage between grinding rollers and grinding track is relatively low. The thickness of the material bed between roller and table is a multiple of the particle size.
Thanks to the integrated separator (classifier) the grounded material is separated after each passage. In comparison to a ball mill (with external separator), the separation is sharper. Therefore the particle size distribution (PSD) of the cement has the tendency to be narrow (high n' according RRSB). This feature is very advantageous for the production of Portland-Limestone Cement.

SikaGrind®
FOR PORTLAND CEMENT

The production of Portland Cement (OPC, CEM I) with Vertical Roller Mills can demand the following benefits from a Grinding Aid:

- Increased production rate, energy saving
- Higher fineness, faster strength development
- Reduced vibration, less wear
- Reduced water injection, less pre-hydration
- Improved particle size distribution, better concrete workability
- Higher powder flowability of the finished cement, good de-loading of silos and trucks

A high content of very fine particles on the grinding track usually troubles the stability of the grinding bed. Fine particles lower the interparticle friction, which reduces the grinding efficiency. Fines on the grinding table cause struggle with the compaction and de-aeration, resulting in vibration and higher wear of the equipment. Water injection is a common method to overcome these problems, but due to the pre-hydration of the cement this possibility is limited and surely doesn't improve the cement quality.

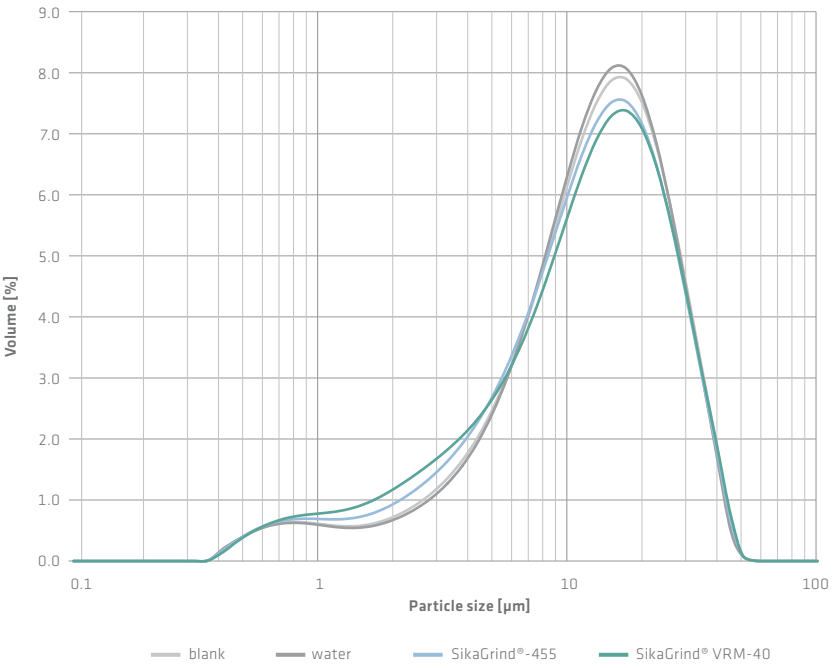
SikaGrind® is preferably sprayed onto the material bed, close to the rolls.

Frequently appears the opinion that the Grinding Aid should stabilize the material bed by a sticky effect. The result of Sika Research and Development, combined with pragmatical tests on a pilot mill of Loesche GmbH in Germany, proved something else. State of the art for Grinding Aids is:

- Increase the share of coarse particles on the grinding track to obtain high interfriction
- Improve the properties of the finished cement

Pilot Mill (Picture: Loesche GmbH, Germany)

Concrete producers dislike cements with narrow PSD's because this can decrease the concrete workability. Counteractive measures of the VRM, as e.g. higher grinding pressure, are used to increase the share of very fine particles (diameter below 5 µm) if necessary. Advanced cement additives, specifically designed for VRM, can be a helpful support for the cement industry to broaden the PSD and increase the productivity at the same time.



Cement particles with a diameter below 3 µm are known to have no or very little influence on the strength development. On the other hand, the graph above shows that SikaGrind® VRM-40 shifted a considerable share of the cement particles into this range. Thanks to improved workability and the chance to lower the water/cement - factor, the concrete strength will profit from this PSD.

RECOMMENDATION

Cement qualities for non-structural applications with low specific surface (low Blaine) are no technical challenge for VRMs, unpretentious Grinding Aids will show a perfect cost/benefit ratio. Sophisticated cements or certain process limitations, e.g. a bottle-neck, demand a Grinding Aid with the highest effectiveness.

Our knowledge of strength and performance enhancer can be applied for cements from ball mills as well as from VRM's.

Portland Cement (ASTM C150) or CEM I (EN 197-1)

Requirement	Product	Characteristics
Recognizable increase of production rate Moderate improvements of cement quality	SikaGrind®-421	Economic treatment cost Typical dosage: 0.05% Chloride free
High increase of production rate Significant improvements of cement quality	SikaGrind®-455	Moderate treatment cost Typical dosage: 0.05% Chloride free
Highest impact on productivity, e.g. as solution for a bottle neck in production process Top improvement of cement quality, e.g. as solution for premium quality cement	SikaGrind® VRM-40	Significant treatment cost Typical dosage: 0.05% Chloride free

SikaGrind®
FOR SLAG CEMENT

Granulated blast-furnace slag (GBFS or GBS) is a by-product of the steel industry. By water quenching of the molten iron slag a very dense and glassy product with an appearance like coarse sand is generated.
Slag Cements are well-recognized in many countries with traditional and powerful steel production. High chemical resistance, low heat of hydration and sustainability are strong arguments for Slag Cements. The main disadvantage of Slag Cement is the slow strength development.

Granulated blast-furnace slag is difficult to grind:

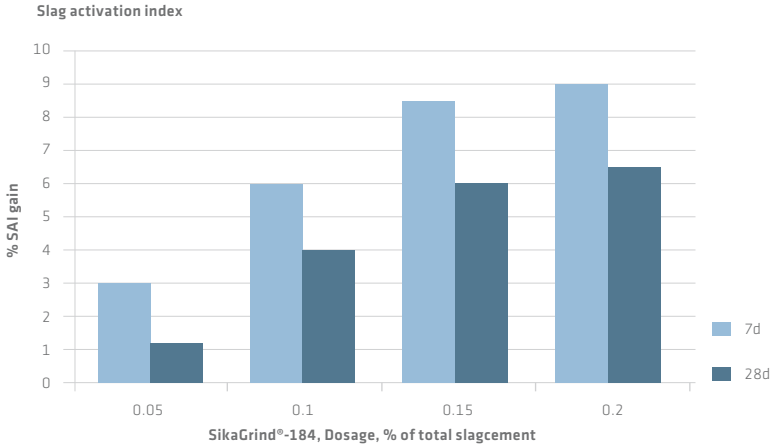
- Slag requires 30-50% more grinding energy than clinker to achieve the same fineness
- Slag needs a higher fineness to reach similar early strength as Portland Cement
- The microstructure of slag is very abrasive which causes high wear of the mill
- GBFS has typically a high moisture content (up to 15%) when delivered to the cement plant

VRM are meant for grinding slag since the specific advantages of VRM fulfill exactly these challenges. Not for nothing, VRM have a share of more than 90% of the delivered slag mills since years because:

- The specific energy demand is lower
- VRM are suitable for grinding and drying of considerable moisture content in one unit
- The wear of the grinding equipment is easier manageable

Slag and clinker are mostly ground separately to minimize energy consumption and optimize the fineness of each component. If storage and mixing facilities are available, a wide product range can be confected.

RECOMMENDATION
Wet slag is usually ground without any cement additives, the moisture helps to form a stable grinding bed. The improvement of the grinding efficiency of dry slag by Grinding Aids is less pronounced as with clinker. Therefore, more interest is paid to the chemical activation of the slag reactivity, especially at early age. The strength increase can just as well be utilized to increase the production rate at lower fineness.



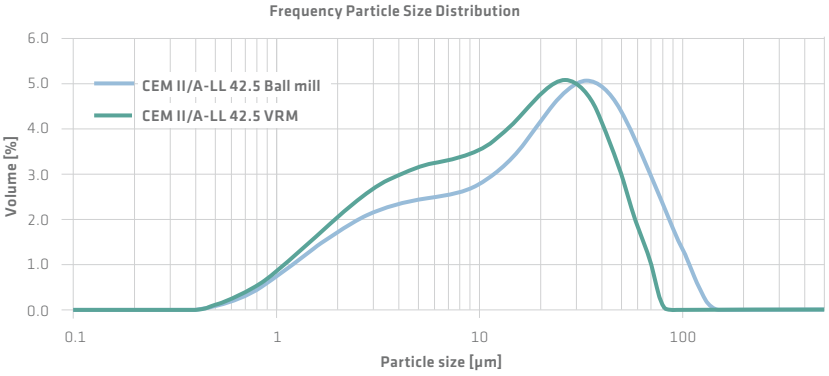
Slag (ASTM C 989 and EN 15167) or Slag cement (ASTM C 595 and EN 197-1)

Requirement	Product	Characteristics
Recognizable increase of early strength	SikaGrind®-200	Minor treatment cost Typical dosage: 0.04% Chloride free
High increase of early strength	SikaGrind®-120	Moderate treatment cost Typical dosage: 0.15% Contains Chlorides
Very high increase of early as well as final strength	SikaGrind®-184	Significant treatment cost Typical dosage: 0.15% Contains Chlorides

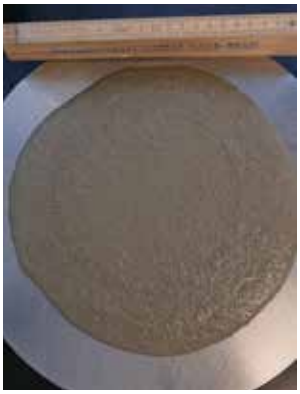
SikaGrind®
FOR PORTLAND-LIMESTONE CEMENT

Limestone is much easier to grind than clinker. The common intergrinding of limestone and clinker in classical ball mills is therefore producing a cement of very high surface. The higher the limestone content, the higher the negative impact of its surface on water demand and powder flowability. The intergrinding of Portland-Limestone Cement (PLC) with Vertical Roller Mills avoids excessive limestone surface.

Particle Size Distribution of 2 cements with identical limestone content, ground in different mill types.
The VRM grinds the clinker to a higher degree, but the fineness of the limestone is not increased proportionally.



Standard mortar without SikaGrind®



Standard mortar with SikaGrind® LS-43

Consistence of standard mortar by flow table

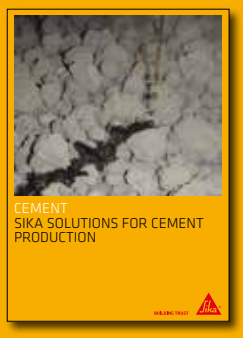
RECOMMENDATION

Portland-Limestone Cements are by all means predisposed for strength enhancing additives, for early as well as for final strength. But the effect of strength enhancers by chemical activation is limited.
The strategy of SikaGrind® LS is to compensate the strength loss with strength enhancers as far as it makes sense and increase the surface, predominantly the clinker fineness, additionally. Eventual impacts of the higher surface on productivity, powder flowability or workability are reduced by SikaGrind® LS.
Sika is successfully using Polycarboxylate ether (PCE) as component of cement additives for PLC in order to reduce the water demand and increase the workability.

Limestone Cement (ASTM C595 and EN 197-1)

Requirement	Product	Characteristics
High increase of early and final strength Increase powder flowability	SikaGrind®-700 SikaGrind®-870	Minor treatment cost Typical dosage: 0.04% Chloride free
High increase of early and final strength Improve concrete workability Increase powder flowability	SikaGrind® LS-273	Moderate treatment cost Typical dosage: 0.10% Chloride free
Very high increase of early and final strength Top improvement of concrete workability High increase of powder flowability	SikaGrind® LS-43	Significant treatment cost Typical dosage: 0.15% Chloride free

ALSO AVAILABLE FROM SIKA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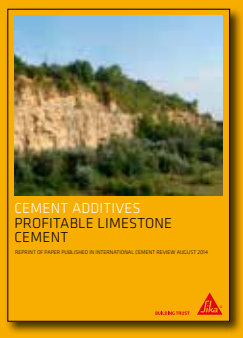
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PROFITABLE LIMESTONE CEMENT
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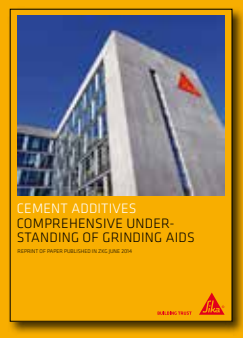
CEMENT ADDITIVES
COMPREHENSIVE UNDERSTANDING OF GRINDING AIDS
REPRINT OF PAPER PUBLISHED IN ZKG JUNE 2014


CEMENT ADDITIVES
CEMENT ADDITIVES BASED ON PCE
REPRINT OF PAPER PUBLISHED IN ZKG INTERNATIONAL OCTOBER 2011

FOR MORE CEMENT INFORMATION:

WHO WE ARE
Sika is a specialty chemicals company with a leading position in the development and production of systems and products for bonding, sealing, damping, reinforcing and protecting in the building sector and the motor vehicle industry. Sika's product lines feature concrete admixtures, mortars, sealants and adhesives, structural strengthening systems, industrial flooring as well as roofing and waterproofing systems.

SIKA SERVICES AG
Tüffenwies 16
CH-8048 Zürich
Switzerland

Contact
Phone +41 58 436 40 40
Fax +41 58 436 41 50
www.sika.com

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