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NEW SOLUTIONS FOR CEMENT AND CONCRETE – INNOVATION MEETS SUSTAINABILITY

The cement and concrete industry is one of the key pillars of the global construction sector. Without cement, there would be no stable buildings, roads, or bridges: it is the binding agent of modern infrastructure. Every year, billions of tons of cement are produced worldwide to meet the growing demand for housing, transportation networks, and industrial facilities. The industry is characterized by stringent quality requirements, complex chemical processes, and continuous development toward more sustainable and energy-efficient material technologies.

For laboratories, this means precise analyses, reproducible testing methods, and reliable sample preparation to ensure the performance, safety, and compliance of concrete products with applicable standards.
At the same time, the industry is at the center of the climate debate. Approximately 7–8 % of global CO_2 emissions originate from cement production, a challenge that demands both innovation and responsibility.

Why emission reduction is crucial

A significant portion of emissions arises unavoidably from the calcination of limestone:

$CaCO_3 \rightarrow CaO + CO_2$

Around 50 % of CO_2 emissions are process-related, while additional shares result from the use of fossil fuels and electrical energy for grinding and conveying processes. Even with a complete transition to renewable energy, this chemically inherent CO_2 release remains unavoidable.

Key strategies for emission reduction therefore include:

- Reduction of clinker content
- Use of alternative materials (SCMs)
- Utilization of recycled materials
- Use of secondary fuels
- Innovative activation methods such as mechanochemistry

Research laboratories play a key role by developing new formulations, evaluating material properties, and validating industrial processes.

Planetary Ball Mill PM 100

The classical cement manufacturing process and its challenges

In the conventional production process, limestone, clay, sand, and iron ore are crushed and ground into raw meal. This material is burned in a rotary kiln at approximately 1450 °C, forming clinker. The clinker is then ground together with gypsum and other additives such as granulated blast-furnace slag or fly ash to produce cement.

All raw materials, intermediate products, and final products must be continuously tested. Reproducible sample preparation using jaw crushers, laboratory mills, sieve shakers, and presses, for example from RETSCH, is indispensable for this purpose.

Jaw crusher BB 600

Homogenizing typical materials in the cement process

Limestone and Clay

Limestone and clay are the primary constituents of cement. For quality control, these materials must be homogenized. Depending on the process, jaw crushers such as the compact BB 50 or high-performance models up to the BB 600 are used for pre-crushing. Alternatively, hammer or impact mills such as the HM 200 are suitable.

Fine grinding down to < 40 µm is typically performed in ball mills. Depending on sample volume and target particle size, solutions range from RETSCH mixer mills such as the MM 400 to planetary ball mills like the PM 100, PM 300, or PM 400, and drum mills such as the TM 300 for larger sample quantities.

Mixer Mill MM 400

Clinker, Cement, and Concrete

Clinker is significantly harder and more abrasive. After pre-crushing in a jaw crusher, robust mill types such as cross-beater or vibratory disc mills like the RS 200 or RS 300 are used. These combine high throughput with very short grinding times and achieve final finenesses below 100 µm within minutes. For even finer particle sizes, ball mills such as the PM 400 are suitable.

Gypsum – soft but challenging

Gypsum is soft but tends to agglomerate. Proven solutions include combinations of jaw crushers, rotor mills such as the SK 300 or ZM 300, and upstream drying using the TG 200 drying unit. Cyclone modules significantly improve sample discharge and reduce dust generation.

Ultra Centrifugal Mill ZM 300

Before, during, and after grinding: drying, cyclones, and presses

Proper sample preparation does not end with grinding:

- Drying prevents agglomeration and improves reproducibility
- Cyclones ensure low-dust discharge and higher sample recovery
- Presses are essential for reliable X-ray fluorescence (XRF) analys

Programmable presses such as the PP 40 ensure constant pressing forces and holding times, crucial for reproducible analytical results.

Cutting Mill SM 300

Air Jet Sieving Machine AS 200 jet pro

Reliable analysis of secondary fuels

Secondary fuels derived from waste or biomass streams increasingly replace fossil energy sources. These materials are often inhomogeneous and bulky, making representative sampling, sample division (e.g., PT 200), and size reduction – often using cutting mills such as the SM 300 – essential. For plastics or fibrous materials, targeted sample preparation using cyclones, embrittlement, or staged size-reduction concepts is critical.

SCMs and the circular economy: from by-product to valuable resource

Supplementary cementitious materials (SCMs) such as slags, fly ash, pozzolans, or incinerated plant residues replace clinker and significantly reduce emissions. Their preparation requires flexible grinding concepts:

- Slags: jaw crusher → SK 300 or ball mills
- Pozzolans & volcanic rocks: rotor mills (SR 300, ZM 300)
- Biogenic ashes: cutting mills, ZM 300, or ball mills depending on analytical

Mechanochemistry meets cement: activation of clays

Activated clays are among the most promising SCMs. Instead of energy-intensive calcination, mechanochemical activation uses targeted energy input in ball mills to alter crystal structures and increase reactivity. Planetary ball mills such as the PM 100 or PM 300 allow precise adjustment of rotational speed, grinding time, and ball-to-powder ratio. Studies show that reactivity increases significantly with rising energy input until an optimum is reached.

A key tool is the GrindControl system, which monitors temperature and pressure inside the grinding jar in real time. It prevents overheating, enables process control, and provides valuable insights into material composition, for example, through CO_2 release from dolomite-containing clays.

Particle size analysis: precision into the fine range

Particle size distribution has a major influence on reactivity, strength, and workability of cement. RETSCH sieve shakers enable fast, reproducible analyses. For fine powders in particular, air jet sieving machines such as the AS 200 jet and AS 200 jet pro are highly effective, enabling dry sieving below 50 µm within minutes.

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Conclusion

The cement and concrete industry is undergoing profound transformation. Sustainable formulations, alternative raw materials, and innovative processes such as mechanochemistry open new pathways to CO_2 reduction. A prerequisite for this progress is powerful and reproducible sample preparation. With a comprehensive portfolio - ranging from jaw crushers, rotor mills, and ball mills to dryers, cyclones, presses, sieve shakers, and digital process monitoring with GrindControl - RETSCH supports laboratories in ensuring quality, accelerating development processes, and actively shaping the transition toward sustainable cements.