HPGR integration to increase capacity and energy efficiency

As cement producers seek to lower the clinker factor without sacrificing performance, grinding plants must process more material at higher fineness levels, yet most existing ball mill systems were not designed for such demanding conditions. HPGR technology has emerged as one of the most powerful solutions to increase capacity, improve energy efficiency and enable the production of high-performance cements with significantly reduced clinker content.

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In a typical cement plant, the kiln operates as the production anchor, delivering a stable and continuous output of clinker. Even as plants work to reduce the clinker factor, the kiln's throughput generally remains constant. This fixed clinker supply must be fully processed by the grinding plant – regardless of how much supplementary material is added.

However, as the clinker factor decreases, new pressures emerge. To maintain strength development in high-additive cement, the clinker must be ground significantly finer. Finer clinker grinding increases energy demand and pushes ball mills towards their performance limits. At the same time, introducing more additive material increases the total mass flow through the mill. What once was a circuit sized only for clinker and gypsum must now handle substantially more material while simultaneously achieving higher fineness targets.

This combination of constant clinker volume, finer grinding requirements and additional additive throughput often creates a bottleneck in the grinding plant. For example, if the clinker factor is lowered from 95 to 75 per cent, the total throughput is increased by more than 25 per cent, while the fineness target also needs to be raised. Without modernisation measures, the cement mills cannot keep pace with production targets, even though the kiln is operating smoothly. To align grinding capacity with modern cement recipes, many producers turn to technological solutions that expand throughput, reduce specific power consumption within their grinding plant and maintain or improve product quality. Among these, the high-pressure grinding roll (HPGR) system has established itself as the most effective method for significantly increasing the capability of existing ball mill circuits.

Figure 1: the polycom® HPGR

HPGR integration

The integration of an HPGR, such as the polycom® system, before an existing ball mill circuit fundamentally changes the way material is prepared for final grinding. Instead of relying solely on impact and attrition inside the ball mill, the HPGR applies intense compressive forces that create a compacted, micro-cracked feed to the ball mill system. These micro-cracks weaken the internal structure of the clinker, dramatically improving its grindability, and result in improved energy efficiency of the complete grinding system.

Once this pre-treated material enters the ball mill, these advantages become immediately apparent. The ball mill requires far less energy to achieve the desired fineness because the particles are already micro-cracked from the pre-grinding system (HPGR with or without recirculation before the ball mill). This shift in the grinding workload often increases total throughput of the complete grinding system by about 25 per cent compared with a stand-alone ball mill. For plants managing rising additive volumes, the additional capacity is essential: the upgraded grinding system can now process more cement per hour while maintaining the same cement quality as before.

Energy-saving aspects are subsidiary in this first integration set-up. If higher capacity increases are required in addition to major energy savings, a modern combi-grinding system can be implemented.

Combi-grinding mode: the most efficient set-up

Although an HPGR in pre-grinding mode by itself delivers substantial improvements, the most efficient and modern configuration is the combi-grinding system, where an HPGR operates in sequence with a ball mill and a combined separator. This

Figure 2: example flowsheet of combi-grinding system HPGR (1), combined separator (2) and ball mill (3); F = feed, P = product

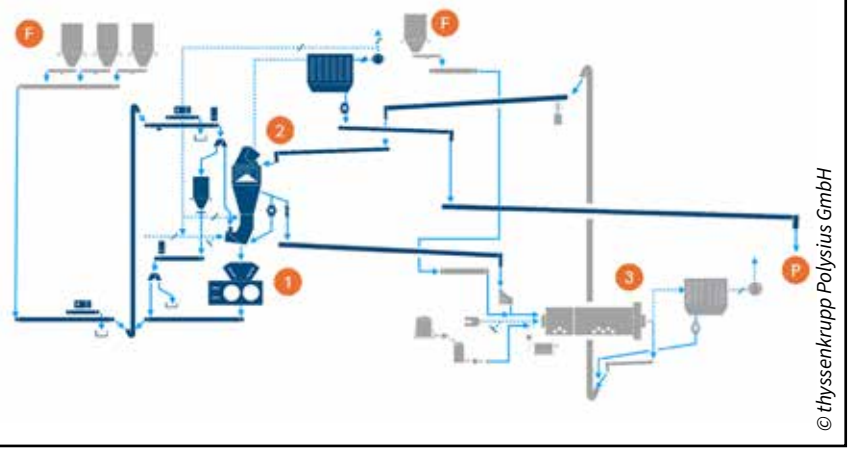
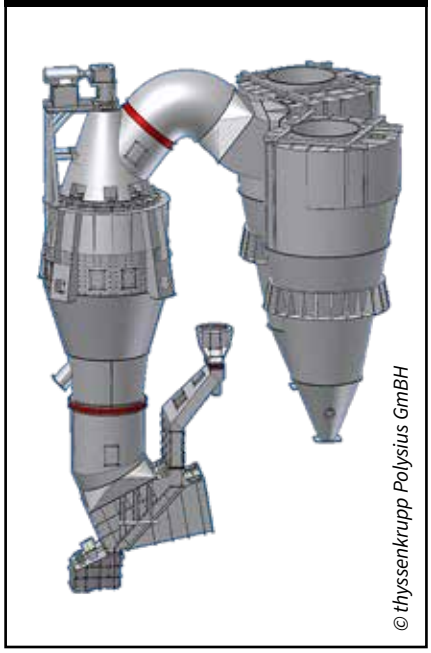


Figure 3: combined separator (sepol® PC)



integrated design allows each component to perform the tasks for which it is best suited: the HPGR excels at high-efficiency size reduction, while the ball mill refines the material to final product fineness with excellent control over the particle size distribution.

In a combi-grinding set-up, the HPGR prepares a feed that fractures easily, allowing the ball mill to achieve the required fineness with significantly lower energy input (see Figure 2). This combination results in a stable, high-capacity system capable of producing fine, reactive clinker and supporting high levels of additive substitution. Unlike stand-alone ball mills, the combi-grinding circuit maintains both high throughput and precise control of the final cement quality. When upgrading a single ball mill to a combi-grinding system, a capacity increase of more than 100 per cent while lowering the specific energy consumption by more than 25 per cent is possible.

A key development in modern combi-grinding is the compact plant footprint incorporating one high-efficiency separator with a static and a dynamic section (see Figure 3). The static separator is dedicated to the HPGR product, removing fines and ensuring that only material requiring further (coarse) grinding is sent back to the HPGR. The airflow including the fine fraction from the static separator then enters the dynamic separator, which manages the final classification, delivering the precise fineness needed for each cement type. The coarse material from the dynamic separator is then transported to the ball mill and/or also back to the HPGR, where it receives its further or final treatment. The fine and final cement exits the dynamic separator within the airflow and enters either a cyclone stage or a filter system. This combined separator reduces circulating loads, increases system stability and enhances product consistency. It also ensures that the very fine fraction within the material from the HPGR, which is already fine and cement-ready material, can exit the grinding circuit on the shortest possible path and has no need to be re- or overground in the ball mill.

The modern layout is also optimised for material flow and space utilisation. Short material conveying distances, vertical equipment arrangements and integrated bypass options reduce system complexity and minimise the need for new construction. The result is a streamlined and space-efficient plant design that fits seamlessly into existing facilities while dramatically improving performance.

Therefore, combi-grinding has become the benchmark for efficient cement grinding, offering unmatched flexibility, high capacity and superior energy efficiency – all essential qualities for producing high-performance, low-clinker cements.

Successful integration of polycom into existing grinding circuits

A customer in south Asia provides a strong example of how HPGR technology can unlock significant performance gains in existing grinding plants. Prior to modernisation, the plant relied solely on a conventional ball mill system that struggled to keep pace with rising demand and evolving product requirements. Increasing fineness targets and growing interest in blended cements pushed the grinding circuit towards its operational limits.

To overcome these constraints, the customer integrated a polycom ahead of the existing ball mill circuit. Once operational, the polycom immediately transformed the circuit's performance by a capacity increase of more than 140 per cent.

In addition to capacity gains, the plant recorded a marked improvement in energy efficiency. The polycom's compressed particle-bed grinding mechanism reduced the overall specific power consumption of the complete circuit by more than 25 per cent and helped the plant stabilise operating costs in a competitive market.

System benefits

Beyond its grinding efficiency, the polycom distinguishes itself through several key engineering features that enhance durability, reliability and long-term performance. These mechanical innovations directly contribute to the system's competitiveness in retrofit and new-build applications alike.

Most important in the operation of HPGRs is the condition of the grinding tools, which are in direct contact with the feed material. With the compound cast rollers (see Figure 4), thyssenkrupp Polysius supplies a wear-resistant design that ensures an exceptionally long service life under the intense grinding pressures characteristic of HPGR operation. The cast-in hard layer withstands immense localised stress and reduces the frequency of maintenance interventions. For plants operating in regions with limited

Figure 4: compound cast rollers in operation

maintenance windows or challenging supply chains, this robustness offers significant operational security. Currently this kind of long-lasting roller is the most-used roller type within the globally installed base of polycoms. It is also available and used as a retrofit for non-Polysius HPGRs. Outstanding lifetimes beyond 80,000h of operation are possible and achieved.

Another stand-out feature of the polycom is its advanced machine protection system (MPS), which ensures safe, reliable operation even under challenging and fluctuating feed conditions (see Figure 5). The MPS continuously monitors key operating parameters, such as hydraulic pressure, roll gap, hydraulic system behaviour, torque values and vibrations on the frame, and intervenes instantly when deviations could jeopardise machine integrity. The MPS prevents damage to critical components and maintains process stability, ensuring that the polycom remains protected without interrupting production. This reduces the risk of unplanned downtimes and significantly extends the lifetime of wear parts and mechanical components. In practice, the MPS gives operators a much higher degree of confidence when running the polycom at elevated pressures – an increasingly common scenario in modern grinding plants. The system acts as a safeguard and optimisation tool alike, supporting consistent throughput, stable operating conditions and a reliable grinding process over long production cycles.

A further standout feature is the re-engineered sliding bearing system (see Figure 6), developed to support the high loads and dynamic forces inherent in HPGR operation. This bearing technology, which is new to the field of high-pressure grinding, provides improved lubrication, reduced friction losses and wear-free operation. Its enhanced structural stability ensures smooth and reliable roller movement, even under variable feed conditions or during high-throughput operation. The reduced mechanical resistance also contributes to lower overall power consumption, supporting the polycom's reputation as one of the most energy-efficient grinding technologies available. Besides these facts, the maintenance friendliness is outstanding.

Together, these design elements – durable compound cast rollers, the MPS system and advanced sliding bearings – form a technological package that ensures long equipment life, reliable performance and reduced operating costs. For producers considering grinding circuit upgrades, these engineering advantages make the polycom an exceptionally robust and future-proof solution.

Figure 5: MPS for the polycom® system

Conclusion

As the cement industry intensifies its efforts to reduce CO_2 emissions and transition to lower clinker cements, grinding plants face unprecedented demands. They must process the kiln's full clinker output, achieve significantly higher clinker fineness and incorporate rising volumes of supplementary materials – all while controlling energy consumption and maintaining cement performance.

HPGR integration provides a decisive answer to these challenges. By fundamentally transforming the grinding of cement, HPGRs unlock significant increases in throughput, reduce energy use and all this while not changing the cement behaviour. When combined with a ball mill in a modern combi-grinding configuration featuring a combined separator, the system becomes even more effective: highly efficient, robust and capable of producing the fine, consistent cement required for low-clinker formulations.

Together, separator upgrades (as featured in ICR, April 2026) and HPGR-based grinding enhancements provide a clear modernisation pathway for cement producers. They allow existing plants to substantially increase performance while supporting the industry's broader sustainability and decarbonisation goals. For operators seeking to future proof their grinding systems, HPGR-assisted combi-grinding represents not just an upgrade, but a strategic investment in the next generation of cement production. ■

Figure 6: polycom® with re-engineered sliding bearing system