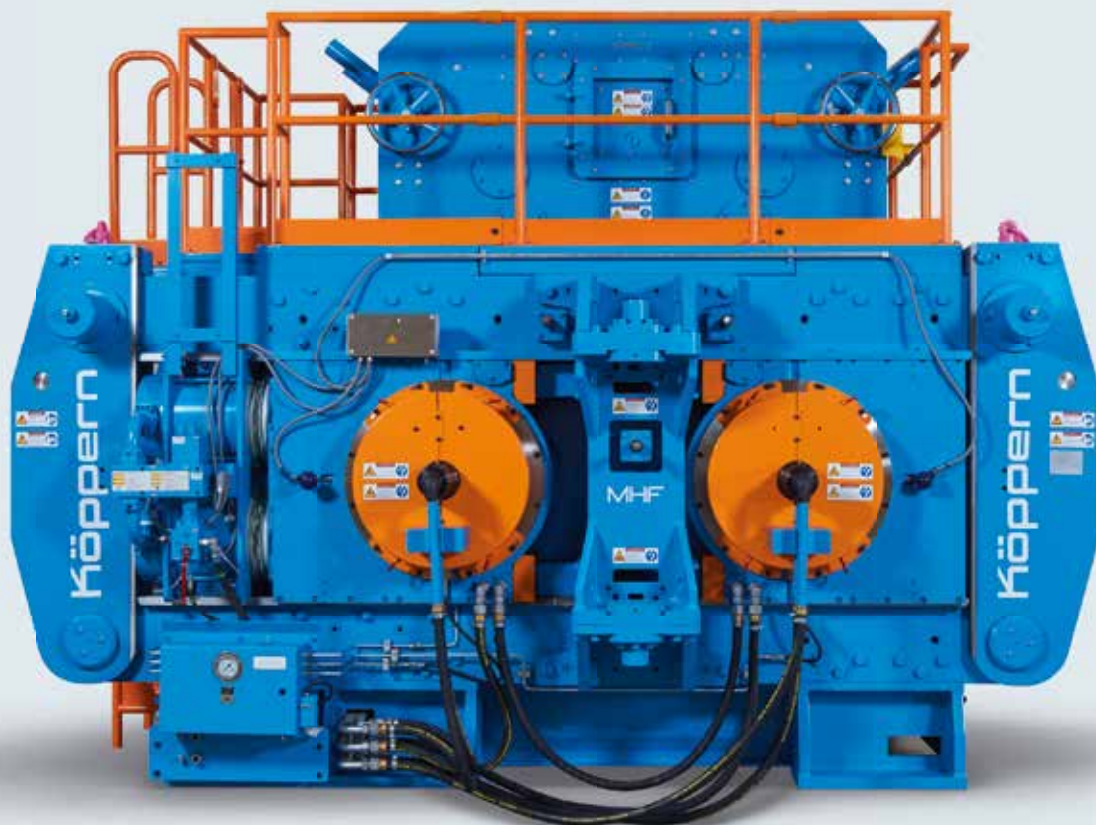


High-Pressure Grinding Roller Presses for Minerals Processing

Specialists in High-Pressure Comminution



Köppern

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Köppern – Specialists
in engineering,
manufacturing and
technical services for
HPGRs worldwide.





Specialists in High-Pressure Comminution

Founded in 1898 in Hattingen, Germany, Köppern remains a family-owned enterprise that continues to reflect its traditional values of technology leadership and highly dependable manufacturing quality, coupled with a unique regard for the individual needs of its customers. Köppern's global network of subsidiaries provides customized services on all continents.

Today, the Köppern Group is a modern, high-tech German group of companies at the forefront of roller press technology. We are dedicated to maintaining and extending our position as one of the world's leading specialists in the manufacture and supply of plant and machinery for the minerals industries.

Innovation Leadership

Since the beginning of the 20th century, roller presses had been used in a variety of industrial applications mainly centered on agglomeration processes for the briquetting and compaction of fine bulk materials. Later, this basic concept has been applied to the design of high-pressure comminution machines. The mid-80s saw the start of a continuous development phase in the area of wear protection for hard-rock grinding surfaces, finally leading to the state-of-the-art HYBRIDUR® system introduced by Köppern in 2012.

Improved Cost-Efficiency

These technological advances as well as Köppern's design improvements have resulted in a significant drop in machine downtimes. The resulting increase in productivity enables our customers to compete more successfully in their own market segments.

If you feel that this can be of interest to your company, we invite you to read on in order to gain more insight into our specialist solutions for high pressure grinding roller presses (HPGRs) relating to the minerals processing industries.

The Köppern Chronicle – Focusing on Comminution

1898

Wilhelm Köppern acquires the "Berninghaus-Hütte" in Hattingen, Germany

1913

First exports to England

1926

The company is renamed "Maschinenfabrik Köppern & Co. KG"

1954–1985

Further development of roller presses for briquetting and compaction. Addition of new markets

1973

Development of Köppern's unique hinged machine frame

1987

Köppern develops roller presses for the comminution of cement clinker

1995

First HPGR for comminution with roller diameter of 2.1 m

1998

Development and successful application of the HEXADUR® wear protection system for HPGR surfaces

2001

Introduction of servo-hydraulic pressure control

2005

First application of Köppern HPGR for goldiferous and diamondiferous ores

2009

Redevelopment of the large mill line

2012

Introduction of HYBRIDUR® wear protection with studded linings

Improved design: MHF – Multi-Hinged Frame

2013

First HPGR delivered for iron ore pellet feed

2014

New HPGR machine sizes introduced ranging from 1.0 m to 2.54 m roller diameter

2018

More than 880 roller presses supplied to 68 countries

62 HPGRs supplied for comminution of ores

Process Technology

Comparison of active grinding zones



HPGR Grinding Process

High-pressure comminution of ores with High Pressure Grinding Roller Presses (HPGRs) is predominantly achieved through compression. The process takes place between two counter-rotating rollers, whereby the ore is choke-fed between the rollers. The feed material is compressed from the bulk density to 70–85 % of the real density and the individual particles are exposed to very high pressure. Comminution takes place in the packed material bed rather than through direct contact with the rollers. This reduces the wear of the grinding tools in comparison to conventional grinding methods such as ball or SAG mills. Additionally, all the material passes through the relatively small but highly intensive grinding zone between the two rollers, leaving no grinding volume unused in contrast to ball mills. Thus HPGRs are extremely efficient in terms of space requirements and wear.

Due to the uniaxial grinding stress, the product shows a substantial amount of completed and incipient cracking emanating from the particle surfaces. Additionally, the particles usually exhibit micro-fractures and other defects which facilitate subsequent grinding and improve the kinetics of leaching, flotation or other separation processes. Grinding with HPGRs therefore helps to optimize the energy requirements and performance of such downstream processes.

In order to achieve proper inter-particle comminution, all feed particles should be smaller than the operating gap between the rollers. This also ensures low wear. The maximum feed size to be processed in an HPGR is a function of equipment parameters as well as ore properties. It therefore varies between certain ranges, allowing the use of HPGRs in secondary, tertiary and quaternary crushing work.

In comparison to conventional comminution equipment, HPGRs produce a high proportion of particles in finished product size. However, due to the nature of inter-particle comminution between the two rollers, the HPGR output may also contain a small amount of oversize particles. Best reduction ratios for all particle size classes are achieved when HPGRs are operated with multiple material passes in closed-circuit operation.

Underlying Process Advantages

Compared to conventional grinding processes, the key advantages of HPGR technology are lower specific energy consumption with higher throughput rates and a large proportion of finished product. This results predominantly from the defined and uniform pressure acting on the material in the gap between the two HPGR rollers.

Comminution within the material bed between the rollers also has the positive effect of reducing their surface wear rate. This effect can be significantly and cost-effectively enhanced by applying Köppern's innovative wear protection systems.



Economic Advantages

In terms of capital and operating costs as well as plant performance, HPGR circuits offer many economic advantages when compared with conventional processing, such as:

- » lower specific energy consumption
- » low operating costs
- » low commissioning times (down to 15 % of SAG mills)
- » higher machine availability due to Köppern's excellent machine design
- » shorter equipment delivery lead times
- » smaller machine footprint and lower foundation load factor
- » steady process throughput
- » ability to adjust process parameters to changing mineral properties
- » higher machine throughput with potentially fewer crushing stages
- » reduced grinding media consumption
- » benefits to downstream processes due to selective comminution
- » preferred particle breakage at mineral grain boundaries
- » low vibration and noise
- » dry grinding aggregate.

Energy and Cost Efficiency

The energy-efficiency of crushing and grinding processes is an increasingly important issue for the minerals processing industry. More than half the energy consumed in the industry is used solely for the size reduction of ores.

As highly productive ores become less abundant, the industry is reaching for harder and poorer deposits, thus placing even more emphasis on the importance of energy-efficient crushing and grinding.

Today, high energy costs coupled with the worldwide initiative to reduce CO₂ emissions have made state-of-the art HPGRs indispensable in many minerals processing industries. These highly efficient comminution machines require considerably less energy compared to conventional crushers and mills, due to:

- » uniform compression of the material between the rollers
- » very short retention time
- » minimal energy requirement for material transport in the HPGR
- » small and 100 % active high pressure grinding zone.



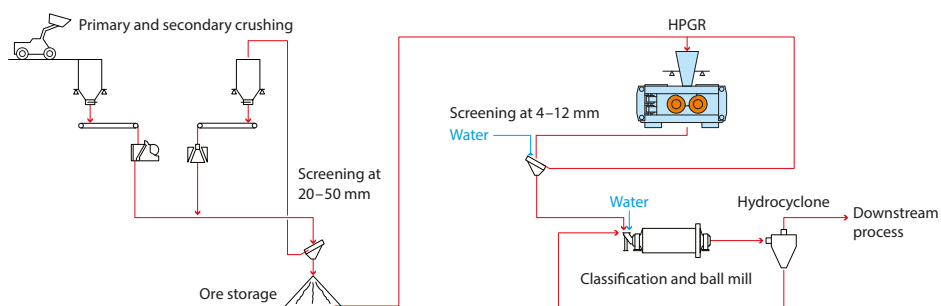
Different ores

Feed material and HPGR product after sizing

Rule of thumb for energy savings with HPGRs

Each kWh/t of grinding power in an HPGR saves up to 2 kWh/t in a downstream ball mill.

Ore Grinding using an HPGR – Example



Pilot Plant – Test Work



Helping you find the best solution

It is always advisable to conduct test work with representative materials in order to assess their relevant properties prior to defining the subsequent processing. This results in an optimized plant layout and keeps investment and operating costs to a minimum. Correct process settings right from the start will boost efficiency throughout plant operation. With our HPGR pilot plant facilities and specialist staff, Köppern is in a unique position to advise and assist customers in assessing the suitability of HPGR technology for their materials and process requirements.

The use of high-pressure grinding machines in minerals processing plants requires special attention to the following issues:

- » Evaluation of ore performance and assessment of process and energy efficiency
- » Careful assessment of ore body and definition of best- and worst-case scenarios
- » HPGR feed preparation in order to ensure the maximum benefit from HPGR technology
- » Evaluation of the treatment of HPGR products and the handling of process recycle materials



Our pilot plant facilities not only support our customers in choosing the right process parameters and roller surfaces, but also by defining the right technical process flow. Years of process-related know-how are concentrated in our pilot plants, so that all the relevant process data concerning the utilization of a roller press can be established under semi-industrial conditions.

Our technical centers are each equipped with HPGRs for comminution tests. These are industrial-scale machines especially suited to testing the comminution behavior of different feed materials destined for grinding.

The machines can be equipped with different roller surfaces. They are connected to the central operating data collection system to facilitate the preparation of test reports.

The test programs aim to:

- » determine process parameters
- » examine recirculation loads
- » analyze feed characteristics
- » select suitable HPGR sizes as well as material preparation and conveying equipment.

In order to simulate the processes required before and after roller press operation, the technical centers are also equipped with mixers, crushers, screens, furnaces and laboratory tools. The process data collected can be used to plan either individual units or complete comminution plants.

If required, the results can be entered in a basic engineering document in the form of a process flow chart to facilitate the definition and choice of components and plant. The additional plant design consists of all relevant lengthwise- and cross-sections of the required building. All relevant information for running the plant (instrument lists, logical diagrams etc.) is included. We are also able to add additional mechanical and electrical equipment to our scope of delivery, or to deliver complete plants. (Read more about the different engineering documents on page 20).

Data from the laboratory and pilot plant are continually updated in line with our field experience. Ongoing co-operations with various mining companies and research institutions also contribute to the continual expansion of Köppern's operational database in order to improve our process and technology knowledge for the best possible support of our customers.

Our main pilot plant facility is situated in Freiberg/Germany. In addition, Köppern operates pilot plants in Western Australia, Russia and North America.



Köppern pilot plant, in cooperation with the Technical University of Freiberg



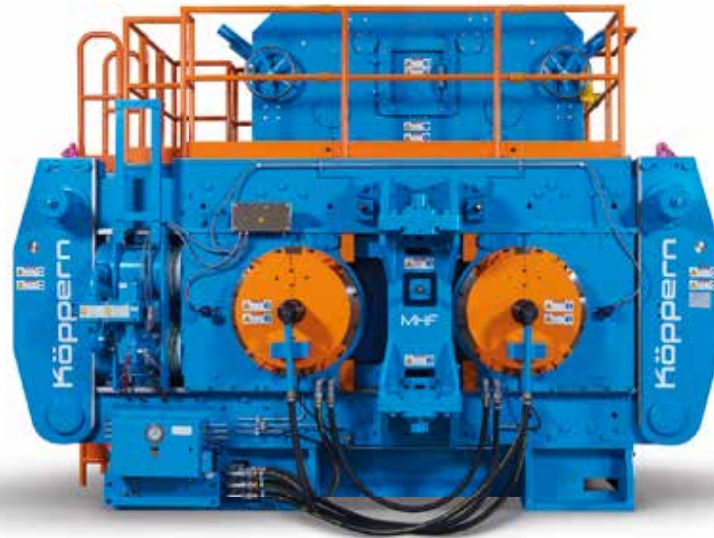
Pilot plant roller press type 52/10



Separator for ore processing



Machine Design



Rollers



Floating roller and pressurizing cylinders



Hydraulic power pack

HPGR: State-of-the-Art for Comminution

The high-pressure grinding roller press (HPGR) is centered around two counter-rotating rollers. These are supported in the frame by spherical roller bearings that are inherently self-aligning and extremely robust. In addition to radial loads, the bearings are able to accommodate axial loads in both directions, making them insensitive to normal shaft-skewing during operation.

The fixed roller is supported directly on the press frame, while the so-called floating roller is supported in the frame by a hydro-pneumatic spring system with hydraulic cylinders that allows for horizontal movement of the roller during operation.

The movement of the floating roller constitutes the basic principle of high-pressure comminution using a roller press. The extent of the roller movement is a function of the selected process parameters and the feed material properties.

Köppern's HPGRs are equipped with a servo-hydraulic system that allows electronic control of the hydraulic pressure independently on both sides of the machine. The grinding pressure can therefore be adjusted precisely across the roller width and skewing can be controlled. This design feature ensures that during the comminution process, all feed material passes through the roller gap under virtually constant conditions, thus ensuring that the output quality remains constant and the machine operates in an optimal and safe condition.

The automatic servo-hydraulic control of the machine increases the stability of the comminution process and the ability of the machine to respond quickly to operator adjustments as well as changing material and feed conditions. The HPGR drive system is made up of electric motors and planetary gear boxes installed at the drive end of each roller. Depending on the application, an HPGR may be designed for constant-speed operation or fitted with variable-speed drives.



Quick roller change with MHF frame and roller transport carriage

The main parameters controlling the comminution process and press throughput are:

- » the process-specific pressing force generated by the hydraulic system
- » roller speed
- » roller width and diameter
- » operating gap
- » feed material characteristics
 - particle size distribution
 - moisture
 - bulk density.

Test work is required in order to validate these parameters.

HPGR Components

A Köppern roller press consists of the following main component assemblies:

- » Hinged press frame for easy replacement of roller assemblies
- » Floating and fixed rollers with wear-resistant tires
- » Main drives with planetary reduction gears
- » Hydraulic pressurizing system
- » Material feeder
- » Housing around the rollers for safety and dust prevention

Factors determining the selection of machine type:

- » Ore type
- » Required application
- » Throughput requirements
- » Necessary specific pressing force
- » Peripheral speed
- » Product particle size
- » Required pressing tools and material feeder



Drive train with motors and gearboxes



Adjustable feeder



Automatic lubrication system

Machine Design

Frame Designs for Rapid Roller Changes

Köppern has developed and patented different hinged frame designs in order to facilitate the exchange of rollers and therefore minimize maintenance shutdowns and expenses. For both solutions, no disassembly of any components of the material feeding system is required.

Hinged Frame

The Hinged Frame is Köppern's classic frame configuration that has been used in more than 350 machines and delivered to some 140 customers since 1973.

The outstanding feature of this design is that the frame is self-supporting at all times, which means both rollers can be exchanged with a minimum of disassembly and reassembly work. To enable this, both ends of the frame are hinged down. The roller assemblies will then slide out on their bearing blocks onto the respective frame ends by means of a winch or an extra motor-driven roller retraction device. From these positions, the roller assemblies are lifted away or transferred to a transport carriage. The steps for the reassembly of the new rollers subsequently take place in reverse order. Approximately 2–3 working shifts are required for a complete change of rollers from shutdown to restart of production.

Multi-Hinged Frame

The Multi-Hinged Frame (MHF) design is a further development of the classic Hinged Frame. This patented design (DE 10 2012 112 102 B3, further patents pending) has all the advantages of the Hinged Frame, but allows both rollers to be removed at one end of the machine. This frame design is therefore particularly suited to situations where space or crane capacities are limited.

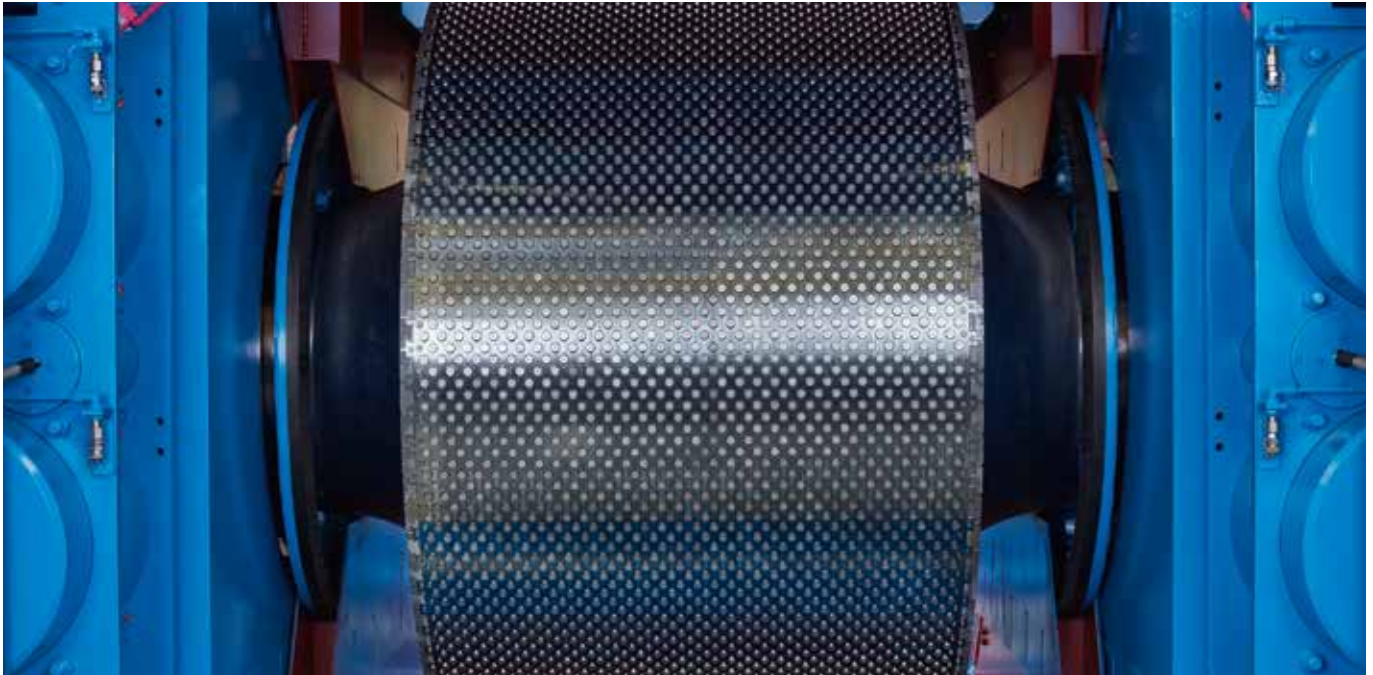
To facilitate the roller change, only one end of the frame needs to be hinged down. The first roller assembly will then slide out on its bearing blocks onto this frame end. From this position, the roller assembly is lifted away or transferred to a transport carriage. The intermediate pieces of the frame are then swung out on both sides of the machine, providing a passage for the second roller assembly to slide out onto the same hinged-down frame end. The steps for the reassembly of the new rollers subsequently take place in reverse order. Approximately 2–3 working shifts are required for a complete change of rollers from shutdown to restart of production.



Hinged Frame design



Multi-Hinged Frame design



Köppern Standard HPGR Sizes for Ore Processing

Köppern has defined a range of standard HPGR sizes which cover most demands of the ore processing industries. In addition to the 34 standard machine sizes, other HPGR configurations are available on request.

Model	Working Surface		Specific Grinding Force (max) [kN/m ²]	Typical Installed Power [kW]	Capacity		Typical HPGR Mass [t]
	Roller Diameter [mm]	Roller Width [mm]			$\rho \sim 1.7 \text{ t/m}^3$ [t/h]	$\rho \sim 2.2 \text{ t/m}^3$ [t/h]	
052–10,0	1,000	250	3,500 to 4,500	2 x 132	50–100	60–130	20
072–11,0	1,100	750–970		2 x 300	200–300	250–400	60
084–12,4	1,240	870–1,120		2 x 450	300–400	400–500	84
092–13,3	1,330	930–1,190		2 x 550	400–500	500–650	103
500–14,5	1,450	1,010–1,300		2 x 725	500–650	650–850	128
560–15,9	1,590	1,120–1,450		2 x 1,000	650–900	850–1,200	177
630–17,6	1,760	1,230–1,580		2 x 1,300	900–1,200	1,200–1,550	219
710–19,2	1,920	1,350–1,730		2 x 1,400	1,200–1,500	1,550–1,950	303
750–20,5	2,050	1,440–1,850		2 x 1,600	1,450–2,000	1,900–2,600	350
900–22,8	2,280	1,600–2,060		2 x 2,100	2,000–2,500	2,600–3,250	458
950–24,0	2,400	1,700–2,180		2 x 2,550	2,400–3,000	3,100–3,900	542
1000–25,4	2,540	1,800–2,310		2 x 3,000	2,800–3,600	3,600–4,700	630

Wear Protection



Challenge and Solution for the Mining Industry

The adoption of high-pressure comminution technology has led to significant inherent savings. The conventional one-piece welded rollers used predominantly in the past for HPGRs were subject to rapid and excessive wear. Today, almost all HPGRs for mineral grinding applications are equipped with rollers assembled with roller cores and shrink fitted tires. These are used with well-proven wear protection systems such as studed linings. Among other advantages, this system allows roller cores to be re-used after the end of the service life of the tires.



Tire surface with studed wear protection

[Tire Surface Wear Protection](#)

The tire surface is protected against wear with the aid of inserted tungsten carbide studs. During the comminution process, the ore embeds itself between the studs and forms an autogenous wear-protection layer for the roller surface. Köppern offers a suitable range of studs aligned to varying ore characteristics. These studs are also available in different lengths. In order to provide reliable and lasting wear protection, Köppern uses only hard metal from reputable suppliers.



Tungsten carbide edge protection elements

[Tungsten Carbide Edge Protection](#)

Tungsten carbide elements are dovetailed directly into the tire. In order to more effectively prevent damage to these edge-protection elements, a separate pocket is provided for each element so that they cannot touch each other.

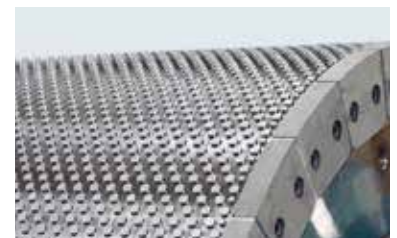


HYBRIDUR® – Edge Protection

HYBRIDUR® combines an innovative, highly wear-resistant edge protection solution with proven stud-lining technology. The outside edge-protection layer consists of elements made of hot-isostatically pressed (HIP) powder-metallurgical material, which is tougher than tungsten carbide and more wear-resistant than welded hard-facing materials. The single HYBRIDUR® elements are each housed in a separate pocket at the edges of the rollers, giving a high level of protection at the sides. The unique design of the HYBRIDUR® system means that there is less chance of chipping at the edges of the rollers in comparison to standard designs.

Cost Efficiency

Rollers fitted with high-quality and state-of-the-art wear protection generate considerable cost savings due to their durability and length of service life. This in turn reduces costs arising from loss of production and repairs, as well as the cost of early tire replacement. These technological advances have resulted in a significant reduction in machine downtime caused by wear and repairs. The resulting rise in productivity, along with a parallel increase in grinding efficiency, enables our customers to compete more successfully in their own market segments.



Studded tire surface with
HYBRIDUR® edge protection

Fields of Application



Pegmatite

Hematite

Magnetite



Copper ore



Gold ore



Kimberlite

Benefiting a Wide Range of Industries

HPGR technology is based on a concept very similar to Köppern's traditionally successful roller presses for briquetting and compaction. Continuous development of innovative wear protection materials and solutions, press frames, drive trains and hydraulic systems has paved the way for entry initially into the cement and subsequently the ores and minerals industries. Since the 1990s, HPGRs have increasingly penetrated applications in mineral processing industries.

In the iron ore industry, HPGRs were first applied around 1994. The machines were initially used to grind relatively fine ore in pre-treatment plants for pellet feed. Since 1997, roller presses have also been used for grinding coarse iron ore and pebbles.

Ores and minerals that are being processed using HPGR technology nowadays include copper, diamond, gold, iron, lithium, molybdenum, nickel, vanadium and others. The HPGRs outperform conventional grinding technologies in terms of comminution efficiency and energy demand.

Key issues for the successful application of Köppern HPGRs in hard ore grinding are:

- » advantages in process technology (see also pp. 6/7)
- » high throughput rates
- » low energy consumption
- » high durability and long service life of roller wear protection
- » low maintenance costs.

In addition to mineral applications, HPGRs are also applied in the cement industry for grinding clinker, slag and limestone.

References

A History of Quality

As a family-run German company with a long and successful history, Köppern has built up an enviable reputation for high end-to-end quality and dependability. This continues to be reflected in our technological development, manufacturing processes, finished products and customer service.

Examples of Applications:



Gold ore | 750/20-1850



Gold ore | 72/10-500



Kimberlite | 500/15-1300



Iron ore concentrate | 500/15-1100



Iron ore | 630/14-1,400



Iron ore | 500/15-1,000

Research and Development

Innovation Leadership

High-pressure comminution process research is a fundamental element of process design in the ore processing and cement industries. Consequently, Köppern has a longstanding tradition of close cooperation with high-ranking German universities and research organizations, including:

[Bergakademie Freiberg](#)

This technical university assists Köppern in process development research for high-pressure comminution, materials handling and abrasive behavior of feed materials.

[Ruhr University Bochum](#)

The Ruhr University Bochum is mainly involved in wear materials research and development.

[RWTH Technical University Aachen](#)

The RWTH Technical University Aachen assists in the field of wear and strength testing of materials.



Köppern has several semi-industrial pilot-plant facilities currently installed at the Bergakademie Freiberg in Germany, the University of British Columbia in Canada and at other research institutions such as ALS Global in Australia and TOMS in Russia.



THE UNIVERSITY
OF BRITISH COLUMBIA

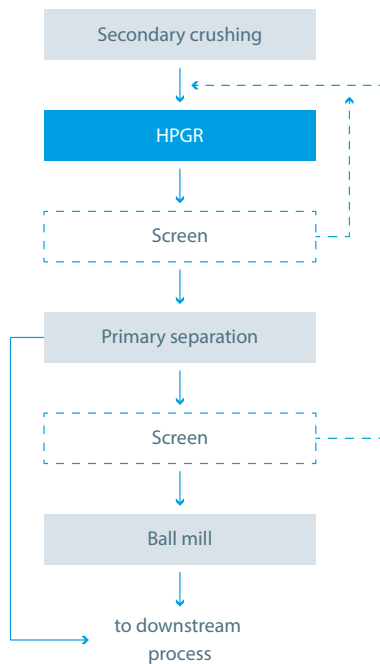


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Process Development and Engineering

Pre-(Coarse) Grinding



Pilot Plant Testwork

Test work is required in the first step in order to assess the relevant ore properties. For further details please see pages 8/9.

Drafting the Process

In order to satisfy the material flow requirements for a particular project, the right combination of ancillary units or machines needs to be determined. These in turn must be carefully selected and accurately specified e.g. for size and performance, and correctly interfaced to optimize the material flow under operative conditions for the entire plant facility.

Project Study

As a prospective customer, you will need reliable information for your business case prior to finalizing your investment. Köppern can provide you with an initial project or plant study covering such topics as:

- » mass flow diagram
- » flow sheet representation of the comminution system with flow lines, quantities, physical and chemical data, operating conditions
- » equipment list
- » plant layout and description
- » CAPEX and OPEX estimates
- » manpower estimate for supervision of erection and commissioning
- » manpower estimate for local erection and commissioning personnel.

Basic Engineering

This document package is designed to facilitate the final investment decision, or to accompany the finalized purchase of the plant. It also helps to save time in the preparation phase of the plant infrastructure.

The scope of this basic engineering package goes much further than the project study by providing detailed specifications of each item of mechanical, electrical or process-related equipment, such as:

- » the relative spatial positioning of the various items of machinery and equipment to ensure cost-effective production as well as efficient access and maintenance
- » short conveyor-belt stretches, coupled with suitable gradients to preclude back-sliding of the material
- » correct angles for the connecting chutes and pipes to ensure feed material is properly transported with respect to gravitational forces.

Control Systems

All Köppern HPGRs are offered complete with PLC control systems to be integrated with plant controls.



Iron ore comminution plant designed by Köppern

Customer Support

Servicing Equipment

Köppern prides itself on its comprehensive and highly flexible full-service package, provided on a 24/7 basis by our own specialists with the proven objective of promoting long-term partnerships with our customers.

Our specialist services include:

- » supervision of installation and commissioning
- » process support and optimization
- » preventive maintenance
- » on- and off-site repairs and maintenance
- » tire replacement services
- » staff training.

Consulting – from simple inquiries to complete concepts

Backed by decades of experience, Köppern offers its customers the support of qualified engineers and technical advisers who are able to assist on-site in:

- » analyzing process-related problems, and
- » providing solutions to optimize your operations and increase your production.



After-Sales Services and Spare Parts



Köppern Customer Service Worldwide

We operate service centers at strategic locations throughout the world to ensure a rapid response to customer requirements for replacement parts, maintenance and repair service as well as our process support services (see also page 21). Experienced personnel from either the Köppern head office in Germany or any of our subsidiaries can be dispatched to your location at any time.



Original Köppern Spare Parts

Original Köppern spare parts are supplied to our customers throughout the world by our service centers or directly from our headquarters in Germany. This helps us to assure correct shipments and short delivery times.



Replacement Tires and Shrinking Services

We supply replacement grinding tires not only for Köppern HPGRs but also for other machine types. The necessary shrinking operations can be performed either in our workshops or on customers' sites with a mobile heat-shrinking device. This electrical device is used for removing used tires as well as shrinking on the replacement tires.



Contact

If you need further information or would like to discuss individual spare parts or service agreements, we kindly ask to contact us at:

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Perth, KMA

Sales and Service Offices

Place your confidence in our worldwide network of service centers and engineering offices. Köppern offers a comprehensive range of customer-focused services starting with process consulting for either your greenfield project or your existing plant update.

- Köppern Headquarters, Hattingen
- Köppern Subsidiary with Sales and Service Offices
- ▲ Köppern Workshops
- Representatives

Worldwide Customer Service

Our specialist services cover pilot-plant test work, plant audits, process layout, engineering, supply of complete briquetting / compaction plants or key equipment, supervision of installation and commissioning as well as training.

Köppern operates service centers at strategic locations throughout the world to ensure a rapid response to customer requirements for spare parts, maintenance and repair services. Experienced personnel from either the Köppern HQ in Germany or any of its subsidiaries can be dispatched to our customers' sites at any time.

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