KHD*
High Pressure Grinding Rolls

Excellent
Minerals
Solutions

WEIR
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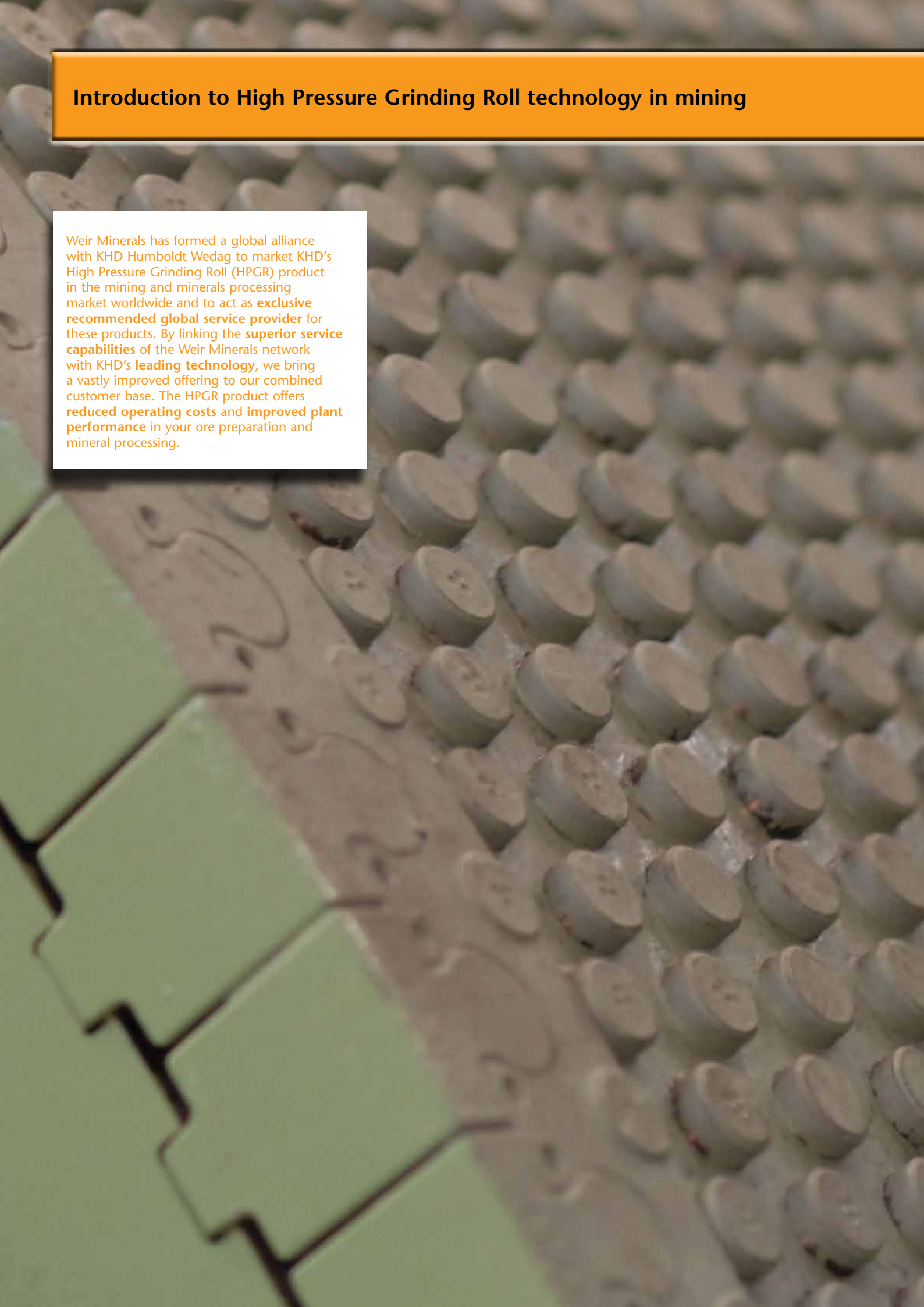
Weir Minerals | KHD
Providing KHD High Pressure Grinding Rolls technology and
Weir Minerals Service to the mining mill circuit worldwide

First choice for HPGR technology and service

*KHD is a Humboldt Wedag GmbH brand used under licence by The Weir Group

Introduction to High Pressure Grinding Roll technology in mining



Weir Minerals has formed a global alliance with KHD Humboldt Wedag to market KHD's High Pressure Grinding Roll (HPGR) product in the mining and minerals processing market worldwide and to act as **exclusive recommended global service provider** for these products. By linking the **superior service capabilities** of the Weir Minerals network with KHD's **leading technology**, we bring a vastly improved offering to our combined customer base. The HPGR product offers **reduced operating costs** and **improved plant performance** in your ore preparation and mineral processing.

High Pressure Grinding Rolls – Crushing and grinding for ore and minerals processing

Introduction

High Pressure Grinding Rolls (HPGR) were introduced as a new grinding technology in 1984. Since then, they have been successfully installed in a large number of plants throughout the world, mainly for cement and limestone. More recently, HPGRs have also been applied in mineral processing plants, largely in iron ore and diamond treatment. In these industries, the application of HPGR ranges from coarse grinding, e.g. the grinding of 65mm (2.5”) size excess pebbles in AG circulation loops, to final grinding of <100µm material to high Blaine values in the preparation of pellet feed.

KHD has a history of successfully installed HPGR units which have demonstrated long term reliability and smooth operation in mining applications.

HPGR grinding significantly enhances overall throughput. This results in the creation of a large proportion of finished product and the reduced Bond Work Index of the pressed material. This generally allows for a reduction in the projected number of equipment units in tertiary crushing, quaternary crushing and grinding.

Benefits of High Pressure Grinding

High Pressure Grinding Rolls (HPGR) offers several benefits to the minerals industry, such as:

- **Low energy** consumption, 0.8-3.0kWh/t
- Ability to **process moist ores**
  - **Fe, Cu, Au ores** **2-6%**
  - **Fe Pellet** **6-12%**
  - **Diamond ore** **2-8%**
  - **Phosphate ore** **3-8%**
- **Enhanced downstream recovery** and grindability
- **Improved grade** of downstream products
- **Low maintenance** requirements
- **Low space** requirements
- **Low vibration** and noise
- **High availability**, >95%
- **High wear surface life**, 4000-36000 hrs

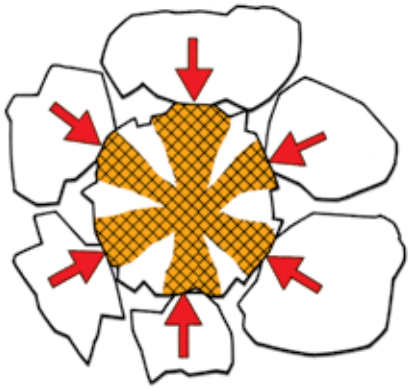
Operating principle

High pressure grinding is achieved by an advanced type of grinding roll. Contrary to conventional crushing rolls, the particles are broken by compression in a packed particle bed, and not by direct nipping of the particles between the two rolls.

This particle bed is created between two choke-fed, counter-rotating rolls. Between these rolls, a particle bed is pressed to a density of up to roughly 85% of the actual material density. This compression is achieved by applying high pressure of up to nearly 300Mpa, exceeding the compression strength of the feed material. During this compacting process the material is ground to a wide particle size distribution with a large proportion of fines, compacted into flakes.

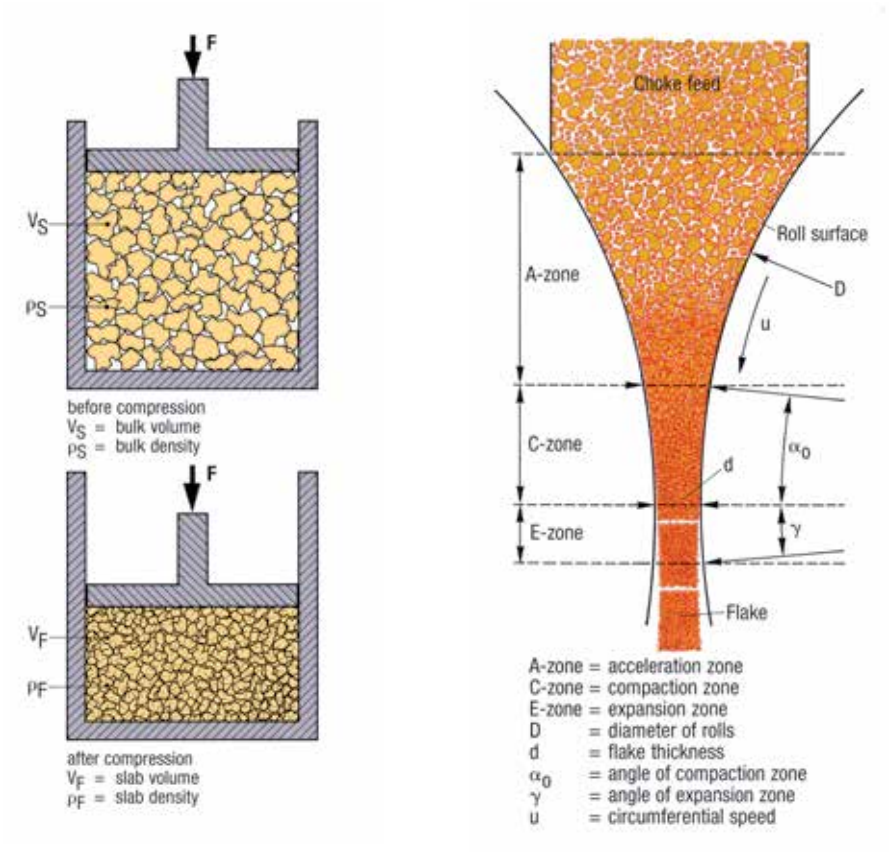
The breakage process can be visualized as consisting of two distinct stages. In the first stage, the choke-fed material entering the space between the rolls is subjected to an acceleration to meet the peripheral roll speed. As a consequence of the narrowing gap between the rolls, the material is gradually compacted and the larger pieces and particles are pre-crushed. Furthermore, a certain degree of

Interparticle comminution: multiple point contacts by particles on a particle



Introduction to High Pressure Grinding Roll technology in mining

Comminution principles: high pressure comminution and breakage process between rollers



particle rearranging occurs, filling the interparticle voids.

In the next stage, the pre-crushed material enters a compaction zone.

This zone involves a gap between the rolls defined by a sector with an angle of about 7°. It is in this compression zone where the pressure occurs. The press force is acting principally on all particles passing the compression zone, through multiple point contacts between the particles in the compressing bed. This results in the disintegration of most particles.

During the process, micro-cracks are being generated within the particles, which results in the weakening of these particles for a subsequent grinding stage. Pressing in a particle bed reduces wear since the main grinding action does not take place between the roll surface and the material, but between the material particles in the particle bed.

The throughput of a HPGR depends on the ability of the rolls to pull the feed into the gap between the rolls (roll surface friction), on the feed material characteristics (e.g. internal cohesion, moisture), and on the operating conditions (e.g. roll speed, choke feed conditions).

The roll surface friction can be increased by applying an articulated surface texture to the rolls, such as a welded chevron pattern or inserted hard-metal studs which protrude a few millimetres above the roll surface (KHD patent).

Product particle size

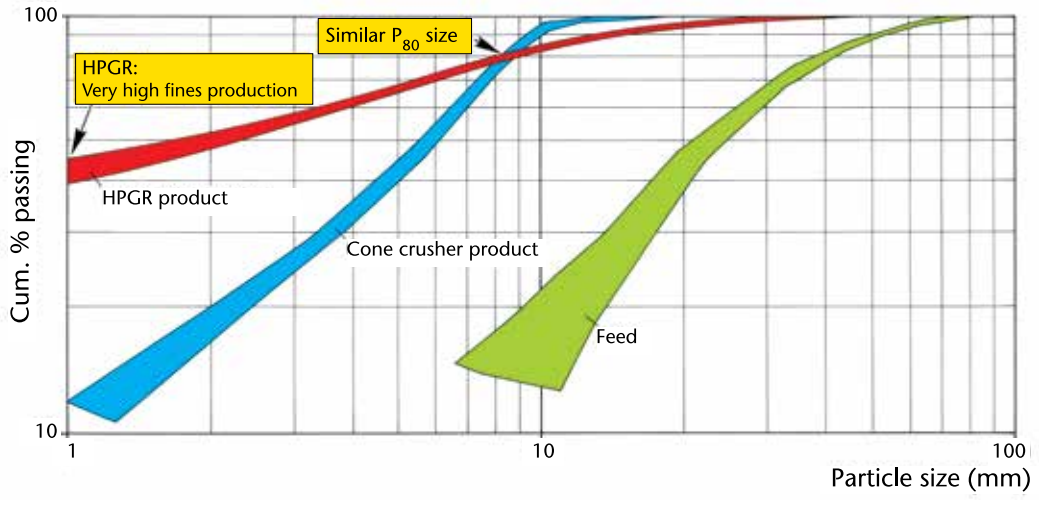
The HPGR is capable of handling particle sizes up to approximately 80mm. The essence of the process is to avoid single particle crushing and to aim for a compressive grinding of the material in the particle bed. Single particle crushing would increase the wear of the roll surface through high point-loads and shear, and would cause damage to the autogenous wear surface. For ideal inter-particle compression, grinding the feed particle sizes should be smaller than the operating gap between the rolls. In actual applications, the top size of a feed distribution can contain particles of up to about 70% greater than the operating gap.

A High Pressure Grinding Roll produces a particle size distribution (PSD) that is wider, with more fines, than a tertiary crusher (e.g. cone crusher) would produce. The reason is that the compressive force not only acts on the coarse end of the PSD, but throughout the particle bed on both coarse and fine particles, including the fine particles derived from the initially coarser fractions.

A wide range of ores appear to generate products of a similar P80. This is the result of the product size distribution at a given press force being linked to the achieved gap opening between the rolls. This gap opening depends on the characteristics of a given ore type in producing a material bed that stands up to the applied pressure, as well as on the roll size.

For instance, for most of the base metal ores tested, the gap opening at a given roll size and an average specific press force of about 4.5N/mm² ranges at about 2.5% of the roll diameter. The maximum particle size in the product is determined mostly by the achieved gap opening between the rolls and a limited amount of feed material bypassing the grinding process (such as at the edges of the rolls). With 100% of the product passing the gap opening size, the slope of the particle size distribution would be determined by the breakage characteristics of the ore under high pressure conditions. A finer size distribution would require a higher press force or, in some cases, a higher moisture content. Most of the products of the HPGR are generally discharged in the form of a flake of compacted material, however of a very fragile consistency. Desagglomeration with a very low energy input may be required in cases where sizing or classification of the products is involved, e.g. in scalping of the finished product sizes ahead of a subsequent grinding stage. If the HPGR is followed by ball milling, generally no desagglomeration of the flake product is required. Given a certain moisture content and relatively low stickiness of the material, the produced flakes readily break down at transfer points of conveyor belts, or in the process of screening when a High Pressure Grinding Roll operates in closed circuit with screens.

Comparison of particle size distribution: High Pressure Grinding Roll v. cone crusher



Advantage of micro-cracks

The high press force in the material bed promotes differential stresses locally within the ore grains, and between the ore minerals and the surrounding waste rock. The ability of the individual minerals to accommodate this stress determines whether they break, deform, or remain unaffected. In diamond processing, the hard diamond mineral resists the stress while the surrounding materials disintegrate, resulting in selective grinding. In gold ores, the bed rock tends to disintegrate, while the gold grains largely resist the pressure or deform very slightly. In other minerals, such as sulphide ores and base metal ores, the different properties of the individual mineral types respond in stress planes along the mineral surfaces. This enhances the mineral liberation.

In leaching operations, the creation of fissures and cracks along the mineral ore boundaries and in the minerals allow for access and percolation of leaching fluids. This tends to enhance the recovery of the valuables.

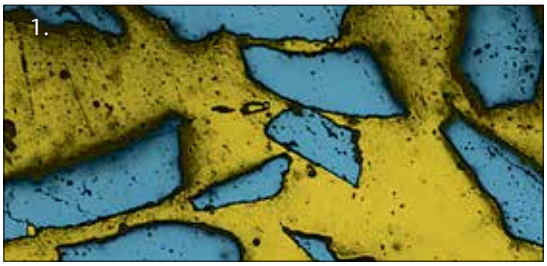
Bond work index reduction

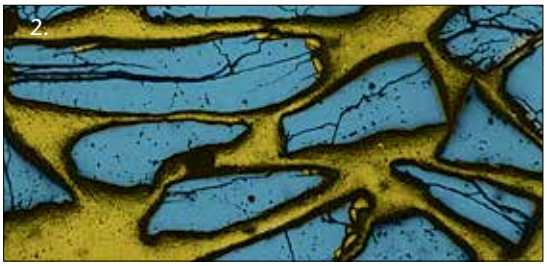
In applications where the HPGR is followed by ball milling, the induced micro fractures generally result in a reduction of the Bond Work Index. For most ores this reduction ranges between 10-25%. Obviously this allows for grinding at either an increased throughput rate, at a reduced power input, or with a reduced number of mills. The reduction in grindability by HPGR grinding can be demonstrated on a variety of ores, both in laboratory and pilot plant scale tests. The reduction in Bond Work Index increases, up to a certain limit, with applied pressure. Combined with an increased fraction of fines in the HPGR product the improved grindability will result in significant cost savings for energy and from reduced labour and maintenance around fewer operating ball mills. This is especially advantageous in operation where power is a costly item, or where it is necessary to maintain the plant capacity where harder or leaner ores are encountered.

Quartzite samples after comminution:

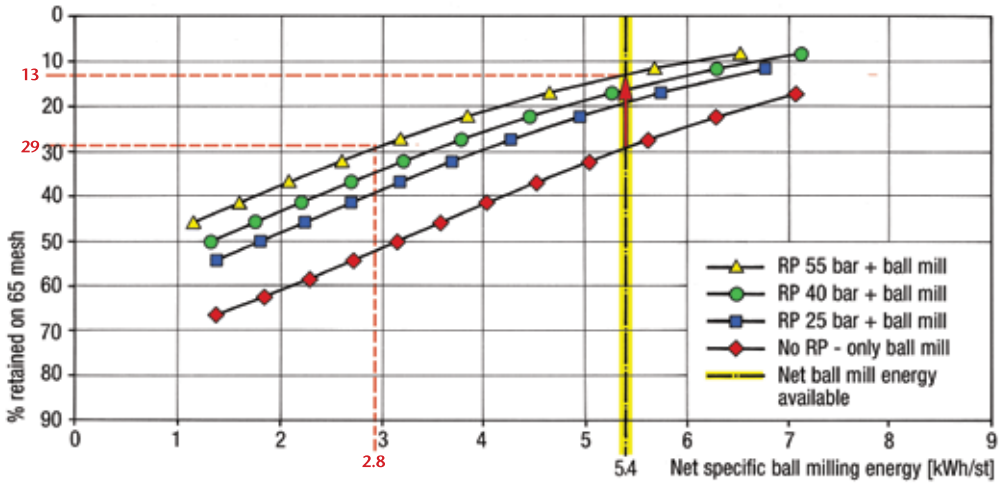
1. from a laboratory jaw crusher

2. from a HPGR – showing myriad micro-cracks





Comparison of bond work index reduction: grinding roll pre-mill v mill alone



Moisture

The feed of a High Pressure Grinding Roll should preferably contain some moisture. This assists in generating a competent autogenous wear surface. Generally, HPGR grinding facilitates the processing of relatively wet ores, in some cases containing moisture of up to 10%. This may be of a significant benefit in those applications where a moist material has to be ground. In a conventional grinding scheme, the ore would require either drying before milling, or wet grinding. Drying is obviously a costly process stage, and wet grinding would require a significant effort in subsequent sedimentation and filtering of the ground ore. In these cases, HPGR grinding can provide a feasible alternative.

Wear protection

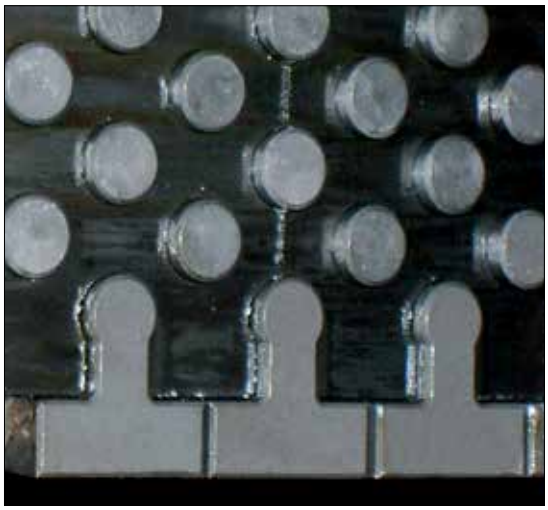
One of the most important subjects in HPGR grinding is the wear of the roll surface. To date, most applications in the cement industry, have hard-faced smooth rolls, frequently with a hard-facing welded rim pattern on the surface for a better surface grip. In the case of minerals, such a surface necessitates high maintenance efforts — often requiring frequent rewelding of these roll surfaces. For this reason, KHD has developed and patented the studded roll surface. These rolls provide a longer wear life due to a more wear resistant surface and the embedding of an autogenous wear layer.

This autogenous wear layer is formed by the ore packing itself between the studs on the rolls. This way the roll surface is coated and protected from the direct wear of the mineral rock.

The autogenous surface generally prevents the larger rocks from a direct impingement on the roll surface, and provides a shield from the abrasive movement of material parallel to the roll surface. The wear thus becomes principally that of the hard metal studs, which are much more resistant.

Actually achieved lifetime hours
of HPGR roll surfaces:

	Operating hours
• Iron ore (pellet feed)	14,000-36,000
• Iron ore(coarse)	6,000-17,000
• Gold ore (coarse)	6,000-10,000
• Kimberlite rock (coarse)	4,000-10,000
• Phospate ore (coarse)	6,000-12,000



Stud-lined surface with autogenous wear surface

Energy consumption

The efficiency of energy utilization is very high. Compared to conventional milling, the selection and breakage characteristics of the process are substantially better, predominantly through the high forces acting on the multiple contacts of the individual particles. The energy consumed is considerably less than in other grinding processes. For most ores, the specific energy consumption is around 0.8–3.0kWh/t. Especially when coupled with subsequent downstream processes or high efficiency classifiers, overall grinding energy reductions as high as 40% have been achieved.

The calculated capacity for a High Pressure Grinding Roll

The calculated capacity for an HPGR can generally be determined by applying the equations as given:

$$Q = q \times D \times W \times v$$

$$Q = s \times W \times v \times r \times 3.6$$

Wherein: Q = *calculated HPGR capacity, t/h*
q = *specific throughput, ts/m³h*
D = *roll diameter, m*
W = *roll width, m*
v = *roll peripheral speed, m/s*
r = *flake density, t/m³*
s = *width of flake, mm*

Capacity

The specific throughput for the High Pressure Grinding Roll is determined from laboratory or pilot plant testing. This specific throughput allows for a more or less direct scale-up with roll size, with certain corrections for roll peripheral speed, press force, gap and moisture content.

The corresponding parameters are given by the size of the High Pressure Grinding Roll and determined from test work on a pilot scale HPGR. The HPGR machine series ranges from pilot rolls, with a roll diameter of 0.8m and roll width of 0.25m, to top size machines with a roll diameter of 2.5m and a roll width of 1.8m or larger.

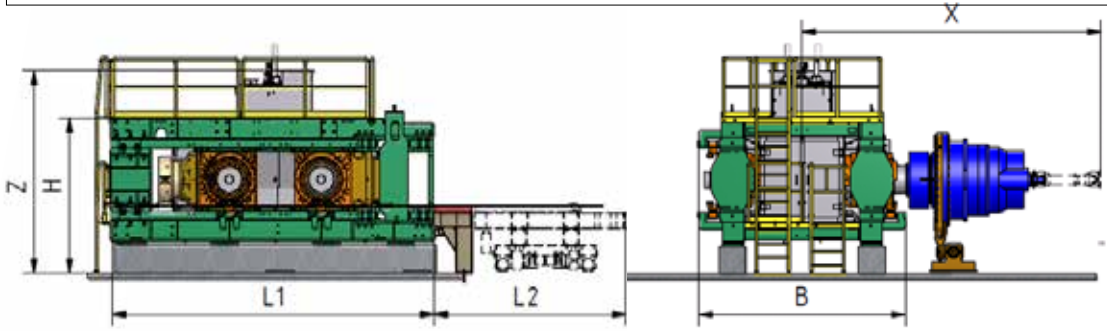
Given an average specific throughput of 250ts/hm³ and a moderate roll speed, the rated capacities for the above machines would calculate to 50t/h and 4000t/h, respectively. Given an average 2.0kWh/t specific energy consumption, the estimated net power consumption would be about 100kW and ~3000kW, respectively.

A summary of the range of KHD HPGR is given in the table below. Obviously, other models and sizes (variation of width of the rolls) are within our scope of supply.

Technical data of main construction series (further High Pressure Grinding Roll dimensions available upon request)

RP size	Roller diameter	Roller width	Capacity Example*	Dimensions						appr. Weight of unit w/o drive
Minerals	D_R (mm)	W_R (mm)	(t/h)	L1 (mm)	L2 (mm)	H (mm)	Z (mm)	B (mm)	X (mm)	(t)
RPS 7 - 140/110	1,400	1,100	400 - 900	5,460	3,890	2,815	3,670	2,920	6225**	94
RPS 7 - 170/110	1,700	1,100	600 - 1300	5,760	3,890	2,815	3,670	2,920	6225**	109
RPS 10 - 170/110	1,700	1,100	600 - 1300	6,050	3,890	2,815	3,670	2,950	6270**	122
RPS 10 - 170/140	1,700	1,400	800 - 1600	6,050	3,890	2,815	3,670	3,250	6270**	134
RPS 13 - 170/140	1,700	1,400	800 - 1600	6,250	3,890	2,815	3,880	3,270	6350**	160
RPS 13 - 170/180	1,700	1,800	1000 - 2100	6,250	3,890	2,815	3,880	3,670	6350**	171
RPS 16 - 170/180	1,700	1,800	1000 - 2100	6,515	3,890	3,225	4,080	3,780	6875**	210
RPM 18 - 200/180	2,000	1,800	1400 - 2900	6,815	3,890	3,225	4,380	3,780	7070**	238
RPS 20 - 220/200	2,200	2,000	1900 - 3900	7,450	3,890	3,225	4,290	4,170	7270**	314
RPM 20 - 260/200	2,600	2,000	2600 - 5400	7,415	3,890	4,045	5,010	4,170	7370**	321
RPM 24 - 300/200	3,000	2,000	3500 - 7200	7,850	3,890	4,045	5,010	4,170	7470**	397
RPM 27 - 300/220	3,000	2,200	3900 - 8000	7,850	3,890	4,045	5,010	4,370	7670**	424

** Coarse Iron Ore, Copper-Gold Ore, Phosphate, Kimberlite, etc.*
*** depend on application*



Application highlights

Although the general benefit of applying high pressure grinding rolls as an effective, low energy grinding concept may generally be applicable, considerations for installation of a High Pressure Grinding Roll are vastly different for every application. A few examples are highlighted below.

Diamond liberation

In the diamond treatment, the most important consideration is an efficient crushing of the ore while at the same time avoiding the breakage of the larger diamond gems. Apart from other benefits, HPGRs are especially suited for the treatment of diamond ores. Contrary to other crushing or grinding systems, any large size diamond gems present in the ore will not be crushed. This is achieved by ensuring that the operating gap is never reduced below a fixed set point (e.g. 25mm). The diamonds can withstand the applied operating pressure, and are not shattered as they have no direct contact with the grinding surface. In tumbling mills (ball mills, SAG mills) or crushers, coarse size reduction occurs through impact, which destroys the larger diamonds which causes a loss of extremely high value gem-quality product.

Precious metal beneficiation

In gold or copper ore treatment, HPGR grinding has been shown to increase the recovery of values. As was indicated above, most ores are susceptible to the creation of micro-cracks in or along the mineral grain surfaces by the high press force. This promotes mineral liberation for gravity recovery, or the access and percolation of leaching fluids rendering the ore more amenable to recovery by leaching. Based on the micro-cracks, a high contact between the leaching fluid and the mineral surfaces is achieved in order to obtain a profitable production.

In addition it has been shown that native gold particles in ores treated by HPGRs are not flattened, in contrast to what occurs in ball mills. This is a result of the typical grinding conditions of an HPGR. As a consequence, separation processes like spiral or centrifugal concentration are more efficient with an improved gold recovery.

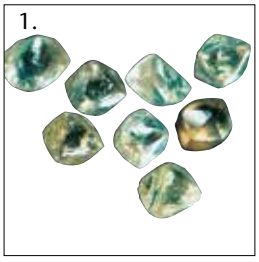
Base metal liberation

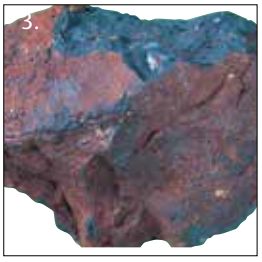
In sulphide ore beneficiation, High Pressure Grinding Roll grinding can selectively increase liberation. The generation of micro-cracks in or along the mineral grain surfaces assists in liberating the locked minerals ahead of gravity concentration, classification, or flotation.

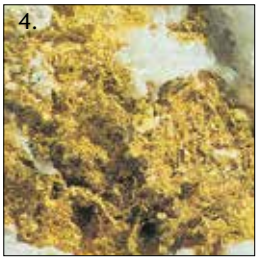
Pellet feed preparation

In iron ore pellet feed preparation, HPGR application as a standalone grinding device or in combination with ball mills has been proven to increase the throughput or ultimate product fineness and pellet quality, at a low level of energy input.

Especially in this type of application, it offers advantages to processing filter cake of beneficiated concentrates. This provides a means of avoiding the need for either excessive drying or difficult filtration and sedimentation processes.







1. *Diamond liberation*
2. *Precious metal beneficiation*
3. *Base metal liberation*
4. *Pellet feed preparation*

High Pressure Grinding Roll test facilities Pilot HPGR

For the execution of pilot scale test work KHD Humboldt Wedag utilizes several pilot HPGRs worldwide. One of these pilot High Pressure Grinding Rolls is installed at the KHD test facility in Cologne, Germany. The location of the other machines depends on the necessity of performing on-site tests for certain projects.

The pilot HPGR is the smallest industrial scale High Pressure Grinding Roll. This means that the test results are very close to the production scale results, thus facilitating realistic scale up calculations to determine the actual process and operating data. For instance, the pilot RP's working width of 250mm has been chosen because the edge effect of a smaller roll width would affect the test results to a great extent. The analysed test data are converted to actual operating data using a special scale up procedure.

All industrial scale HPGRs have been designed based on this procedure. Comparisons between the pilot test results and the data obtained during commissioning of the production scale HPGRs confirm the precision of the scale up procedures.

The pilot High Pressure Grinding Roll at the KHD test facility in Cologne, Germany

Primary objectives of pilot test work:

- Determination of process parameters for the design of industrial scale High Pressure Grinding Rolls
- Estimation of wear behaviour
- Production of test material for downstream processes
- Determination of mechanical design parameters for the industrial scale HPGRs

The pilot machine is equipped with a monitoring and graphic control system. The following process and operating data are monitored and recorded:

- Total and specific throughput
- Total and specific power consumption
- Total and specific press forces
- Gap and flake thickness
- Circumferential roll speed
- Test duration

After treatment in the HPGR further analyses are carried out such as:

- Particle size distributions by wet or dry screening
- Specific gravity, bulk and flake density
- Bond Work Index
- Moisture content
- Investigations of mineralogy
- Wear rate determination
- Chemical analysis
- X-ray analysis

Basic data of the pilot HPGR

The basic data of the pilot HPGR at the KHD test facility in Cologne, Germany:

Roll diameter:	800 mm
Roll width:	250 mm
Max. spec press force	Up to ~ 10 N/mm² **
Capacity:	~ 30-80 t/h(1)
Motor size:	2 x 132 kW
HPGR weight:	~ 21t
Required amount of test material:	~ 100 kg (each test)

(1) depending on the properties of the feed material

*** normal max specific press force for minerals ~ 5 N/mm²*

KHD High Pressure Grinding Roll (HPGR) installations worldwide

The High Pressure Grinding Roll has advanced and improved as a result of practical applications. It has gained a firm footing in comminution technology. Contrary to conventional single particle crushing, e.g. in tube mills, the outstanding size reduction in a High Pressure Grinding Roll is the result of interparticle comminution between the rolls. HPGRs are characterized by high material throughput rates at comparably low capital outlay. The specific energy demand for material comminution is significantly reduced as well. Thanks to these economic benefits, there have been more than 290 machines sold to the cement, ore and mineral processing industry all over the world.

The following pages list typical examples of HPGRs set up for iron ore, gold ore and kimberlite rock comminution and operating to the full satisfaction of our customers in Africa, North and South America, Asia, Australia, and Europe.

High Pressure Grinding Roll applications for ore and minerals processing

Benefits of High Pressure Grinding Roll Utilization

- **Low energy** consumption
- **High ratio** of comminution
- **Selective** liberation
- **High throughput rates** at low footprint
- **Increased lifetime** of wear parts
- **High availability** (>95%), **easy maintenance** and **control**
- **Various areas** for application
- In total: **low operating costs!**

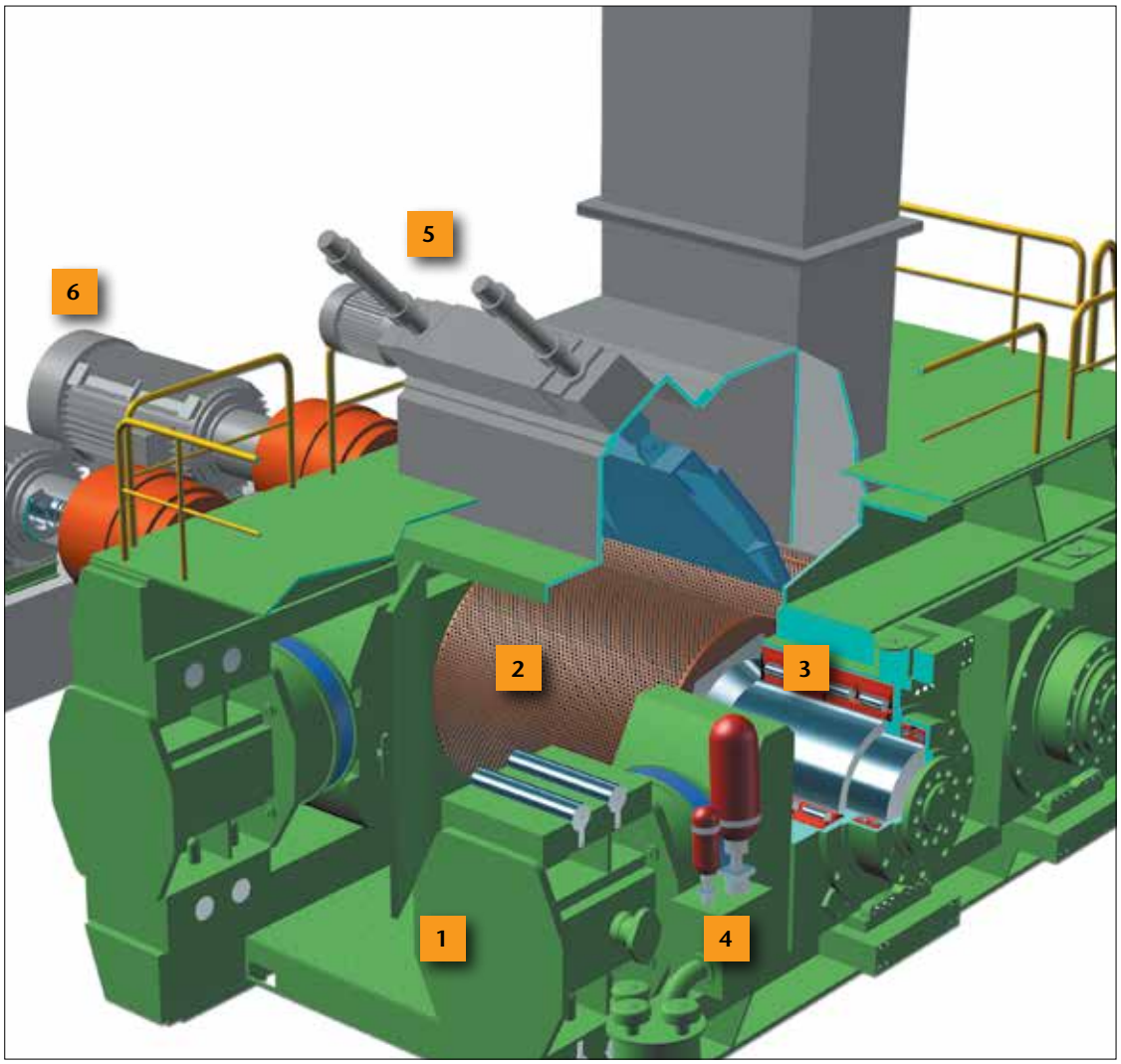
Visual tour of a High Pressure Grinding Roll

The High Pressure Grinding Roll

The components of the KHD High Pressure Grinding Roll are divided into clearly defined assemblies. The major features of our HPGRs are the two press rolls (**2**) horizontally mounted, each supported in a heavy sectional frame (**1**) by the bearing systems (**3**). The surfaces of the rolls are lined with hard metal studs to ensure autogenous wear protection. Deliveries from 2007 onwards are equipped with the stud-lined surface. Centralized automatic oil or grease lubrication systems supply lubricant to the cylindrical or self-aligning roller bearings.

One roll is fixed to the frame. The other roll is movable and free to slide within certain limits. The press rolls are driven individually and the power is transmitted via a cardan shaft, a safety or optional fluid clutch, and standard planetary gears (**6**). Various drive arrangements are available. The material is gravity-fed vertically into the roll gap over the feeding device (**5**) which may be equipped with a regulating gate as necessary. The forces required for optimal size reduction are transmitted by means of a hydraulic system to the sliding roll and thus, in a controlled manner, to the material bed between the press rolls.

The standard control system automatically monitors and controls all relevant operating and machine parameters.

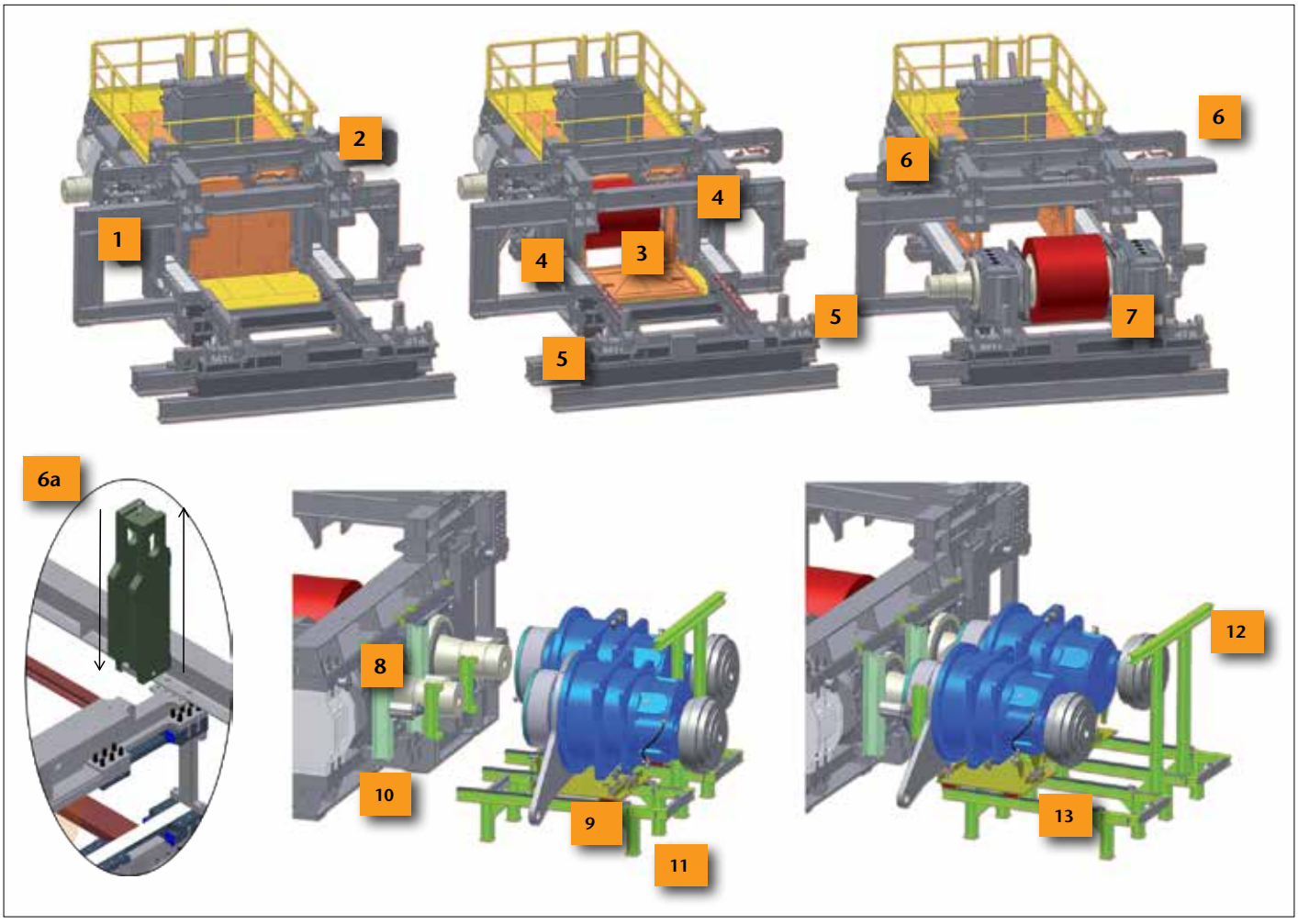


Most important High Pressure Grinding Roll assemblies

1. *Press frame*
2. *Press rolls*
3. *Bearing system*
4. *Hydraulic pressing device*
5. *Feeding device*
6. *Drive*

1. The press frame and roll change

- Removal of both rolls to one side, without frame dismantling
- No need to remove the RP bin, feeding device or hydraulic lines
- Heavy swivelling support plates (optional) (1 operating position, 6 open position); activated by either hydraulic cylinders (6) or standard lifting device (6a)
- Support plates (1) equipped with replaceable, hardened plates
- Easy opening of roll cover by hinge on front side plate (3)
- Permanently mounted frame extension (4) with twin cable winch system (5) for roll removal and installation
- Frame extension option equipped with low friction elements or alternative (7) transport cart
- Gearbox assembly/dismounting option, consisting of hydraulic jacks (8), support/moving plate(9), tie-bars (10), support frames (11) with lifting points for cardan shaft(12)
- Simple, but exact vertical and horizontal alignment by 3 standard hydraulic cylinders and adjustment sets (13)
- Load control of each support point by pressure gauge during assembly and dismounting
- No additional special tools required
- Horizontal movement of gearboxes by standard cable or chain hoist



2. The KHD rolls

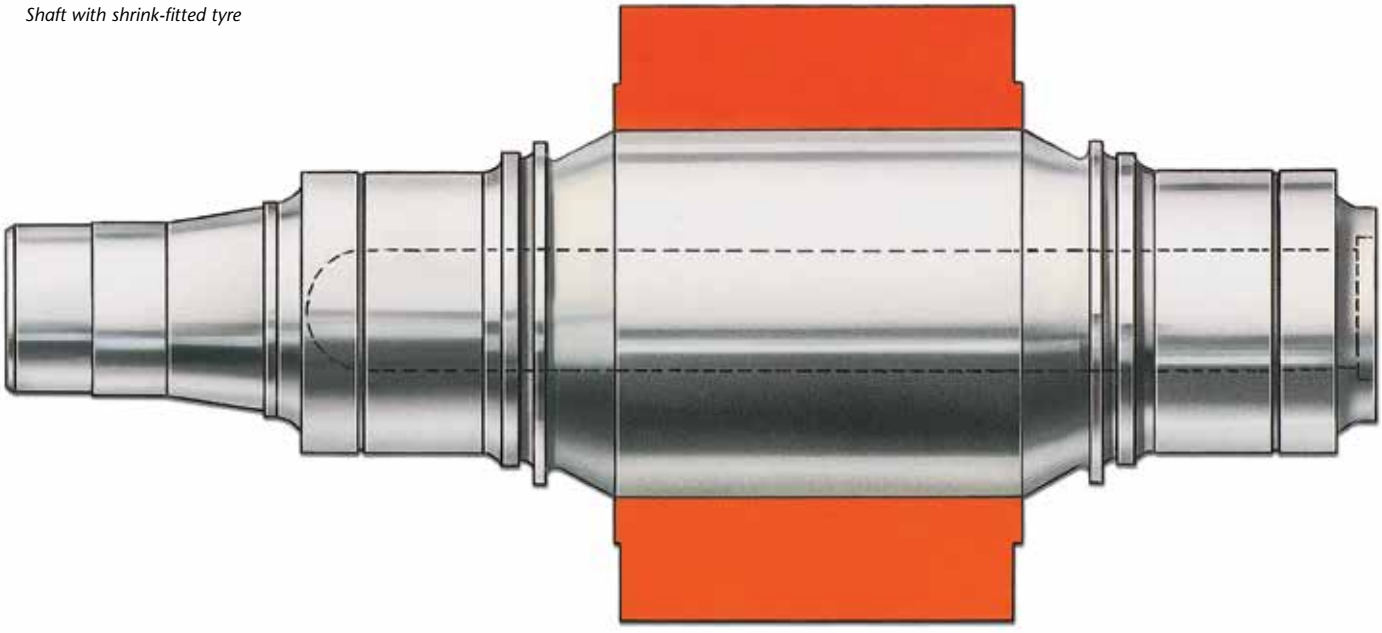
The cost of wear is of major importance in the minerals processing industry. Therefore, KHD has given wear protection top priority. By developing a patented highly wear resistant stud-lining of the rolls, KHD has thus taken a leading position worldwide.

The press rolls are the grinding tools of the High Pressure Grinding Roll. Due to direct contact with the material to be pressed under varying pressures, they may be subject to high wear.

The combination of hard-metal pins (studs) and material embedded between these pins, a system developed and patented by KHD, has gained wide recognition as autogenous wear protection of the roll surface. Obviously, the best wear protection is the material to be pressed. As a further benefit of the studded roll, the nipping properties are significantly improved. Without this improvement it would, for example, not be possible to economically process a difficult material such as moist pellet feed. This patented roll surface system has been further developed to the stud-lined surface and is state-of-the-art technology by KHD. It is highlighted by excellent service cycles. The tyres can be withdrawn from the shafts and replaced when worn down.

Roll with KHD patented stud-lining

Shaft with shrink-fitted tyre



3. The bearing system

Depending on the HPGR type two different bearing systems can be installed: either multi-row cylindrical roller bearings or self-aligning roller bearings. KHD is the only manufacturer that has for many years successfully installed multi-row cylindrical roller bearings in larger HPGRs. This is only feasible in combination with KHD's patented rubber thrust bearing arranged directly in front of the bearing housings.

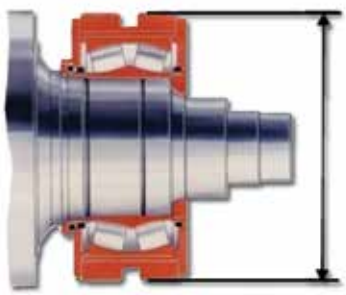
The benefits:

- The floating-roller side can balance the slight angular movements originating from the oblique position, if any, of the floating roller.
- Ensure a homogeneous load distribution onto the antifriction bearings, positively influencing the service life.
- Balance manufacturing tolerances

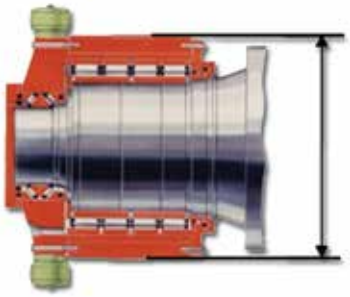
For cost reasons, smaller High Pressure Grinding Rolls are equipped with conventional heavy self-aligning roller bearings. We make use of the benefits of the rubber thrust bearing for this bearing type as well. The main feature of this 3-part rubber thrust bearing is the inlaid rubber sheet. It has the effect of a highly viscous liquid that ensures optimal load introduction.

Another important feature is the combination of polished chromium plates and PTFE-faced sliding plates mentioned earlier (refer 1. The press frame - page 12). That system has been patented, as well, and consists of commercial polished chromium plates and PTFE plates. These assemblies can easily be replaced when worn without disassembly of the rollers and do not require additional maintenance. They are mounted between the bearing housings and the top/ bottom frame as well as to the external guide mechanism of the bearings for axial fixing of the press rolls.

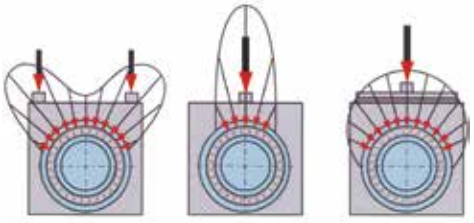
Lubricant is supplied to the cylindrical roller bearings either by an automatic oil circulation lubrication system (bearings) combined with a centralized grease lubrication system (labyrinth seals) or by a centralized grease lubrication unit (bearings and seals). The self-aligning roller bearings are supplied with lubricant only by the automatic, centralized grease lubrication unit. Both types of bearings have been equipped with highly efficient, multistage seals to prevent the penetration of impurities.



System with self-aligning roller bearing



System with cylindrical roller bearing



Double centred load distribution, clamping effect

Drawbacks:

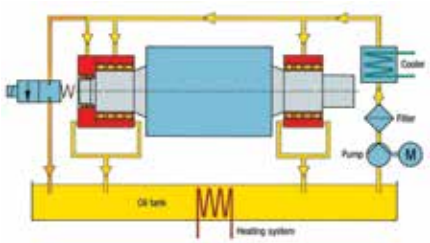
- *Twice passing peak load zones*
- *"Blocking" the rolling elements to deformation of the bearing housing*

Centre load distribution; High load concentration

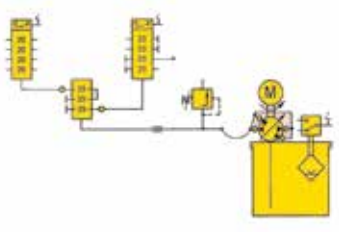
Drawbacks:

- *Load concentration on a few roller rows*
- *Peak load acting on a centre roller row*

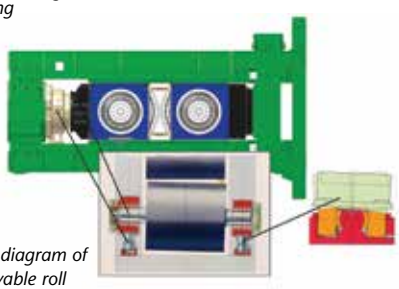
Optimal load distribution



Simplified diagram of the oil circulation lubrication system



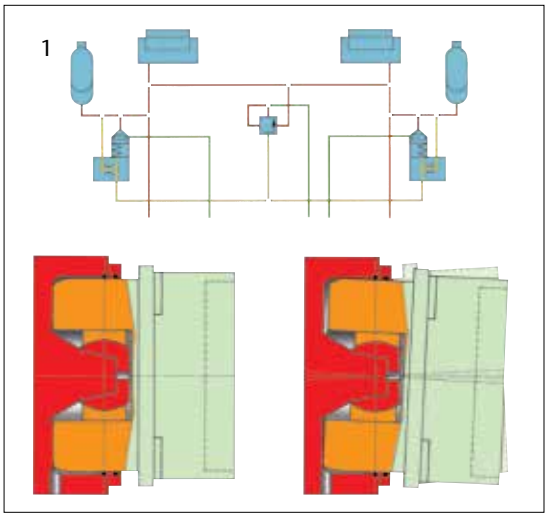
Simplified centralised grease lubrication system



Motion diagram of the movable roll

4. Hydraulic pressing device

The main objective of High Pressure Grinding Roll operation is to attain a satisfactory product at a minimum pressing power. This is achieved with our HPGRs, thanks to the well engineered hydraulic pressing device in combination with the press control system. Optimal operating parameters, that have previously been determined by material tests, are automatically monitored and kept within specified tolerances by the hydraulic control system. Even in case of normal fluctuations of the feed characteristics, an essentially constant product quality is attained. The operator will be in a position to manually control the HPGR for short periods, if required. The major components of the hydraulic set are the two flat jacks. These flat jacks have been jointly developed by KHD and cylinder manufacturers. The most important design features are the piston swivelling to all sides and the separation of sealing and guide surfaces. Only the sealing lip comes into contact with the outer piston diameter. For starting HPGR operation and for service/inspection functions,the movable roll can be displaced by means of the return cylinder that is mounted between the bearing housings of the movable and fixed rolls.



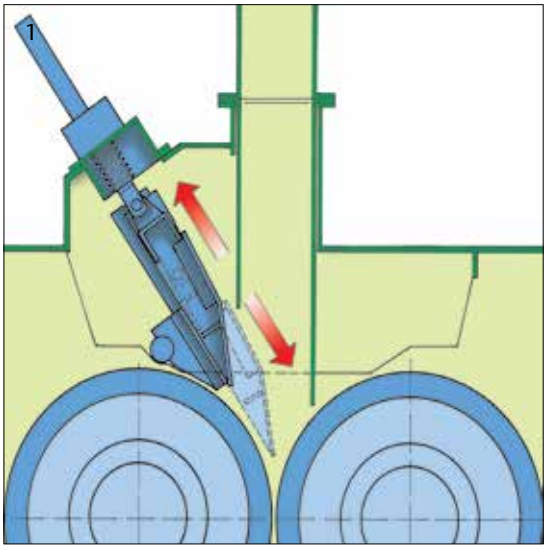
1. *Simplified hydraulic design with a schematic movement of pistons*
2. *Hydraulic tank*
3. *Hydraulic control block*

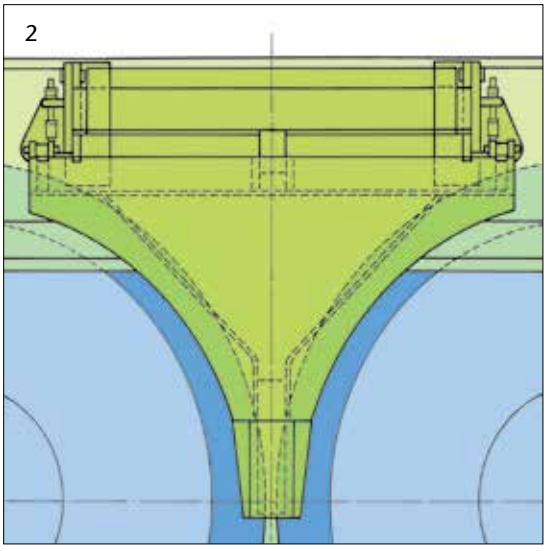
5. The feeding device

The significance of this device is frequently underrated. The method of material feeding has an important influence on steady and vibration-free HPGR operation. Depending on the specific material to be processed, the feeding device can be equipped with a regulating gate and given the most appropriate wear-protection lining.

The cheek plates mounted on both sides are vertically and horizontally adjustable and are an integral part of the feeding device. They ensure that only a minimum of unpressed feed will flow past the sides of the roll faces. The plates are mounted in a manner which enables them to give way upon skewing of the movable roll. In such a case, the cheek plate is pressed back to its original position by means of a pre-loaded spring assembly after the parallel position of the movable roll relative to the fixed roll has been restored.

The cheek plate is of split design to be capable of separately changing the bottom part of the cheek plate, which is subject to maximum wear. This is a further contribution to lower the cost of wear.



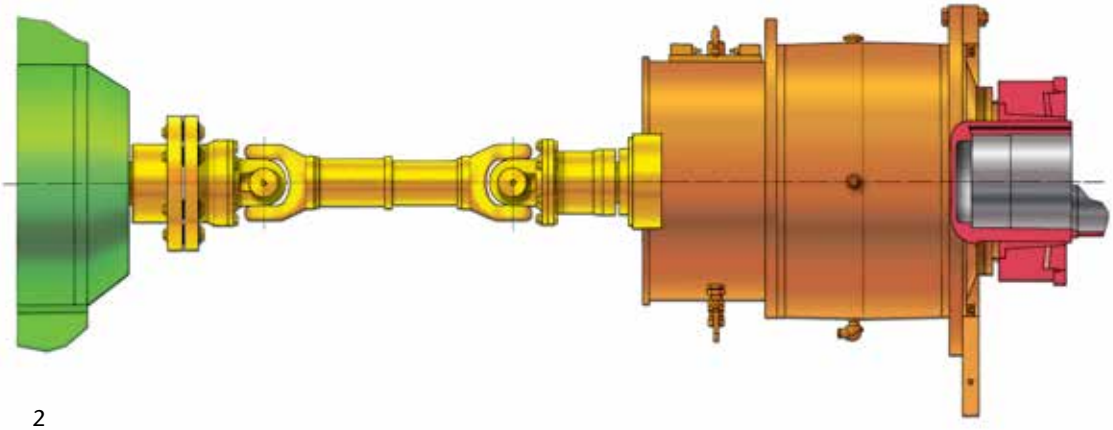


1. *Feeding device*
2. *Cheek plate*

6. The drive

The power to drive the press rolls is transmitted exclusively by standard planetary gears. The gear units are slipped on the press roll shaft directly and reliably, fastened in a simple way by means of a hydraulic shrink disk. The reaction torque is taken up by a specific torque support consisting of lateral, vertical supports and a torsional shaft. A cardan shaft and a safe set clutch (optional fluid clutch available) establish the connection to the motor on the gear input side. This connection is made with a safety clutch for frequency-controlled motors.

1



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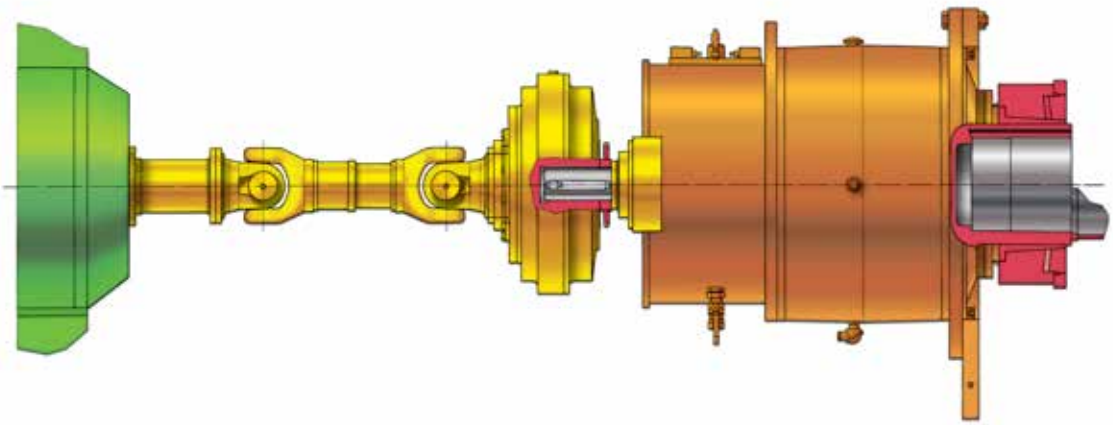


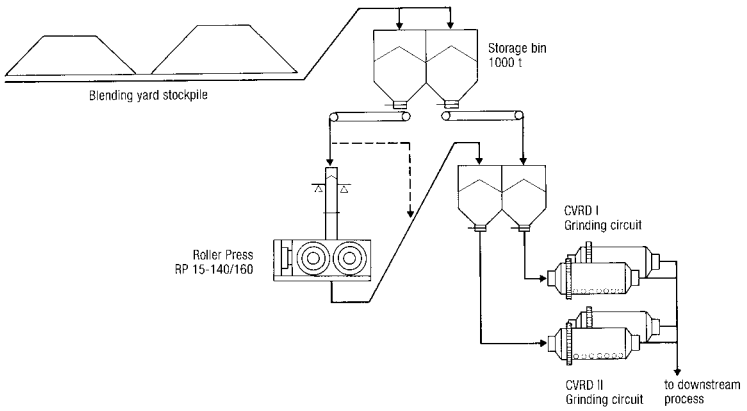
1. *Drive arrangement with frequency converter*
2. *Drive arrangement without frequency converter, optional with fluid clutch*

Case History review

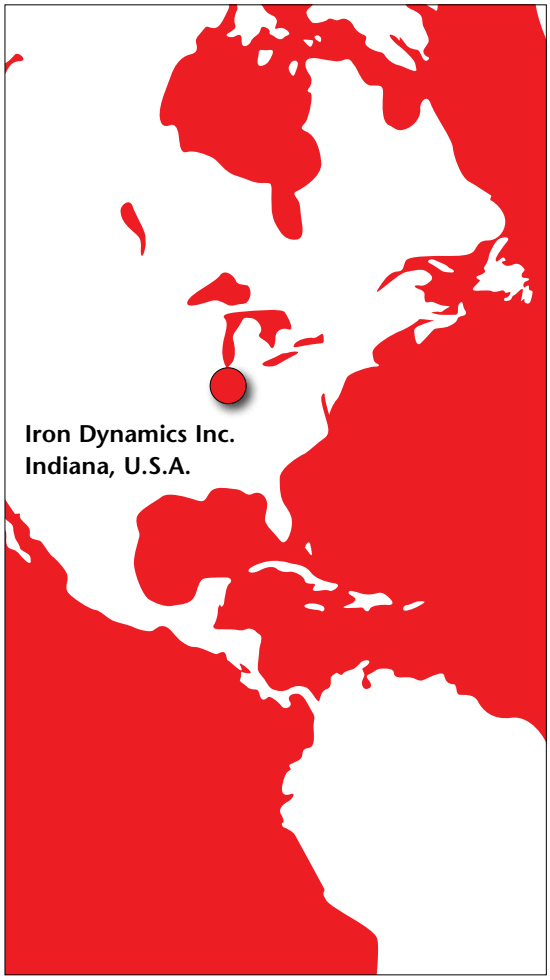
Brazil: HPGR 15 – 140 / 160 for grinding iron ore pellet feed

Brazil: Design and process data

Company / location	CVRD	Vitoria, Brazil
Roll diameter	1,400 mm
Roll width	1,600 mm
Feed material	iron ore pellet feed ahead of ball mills
Feed moisture	8.5%
Feed size	500 Blaine
Final grain size	900 Blaine
Throughput rate	715 t/h
Spec. energy consumption	< 2.4 kW h/t
Specific press force	3 N/mm²
Motor size	2 x 1,750 kW
Lifetime of studded tyres	16,000 operating hours

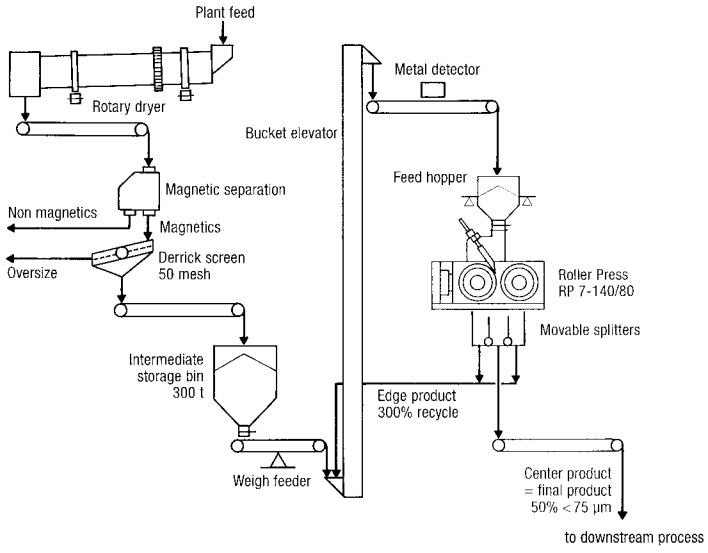


U.S.A.: HPGR 7 – 140 / 80 for grinding iron ore pellet feed



U.S.A.: Design and process data

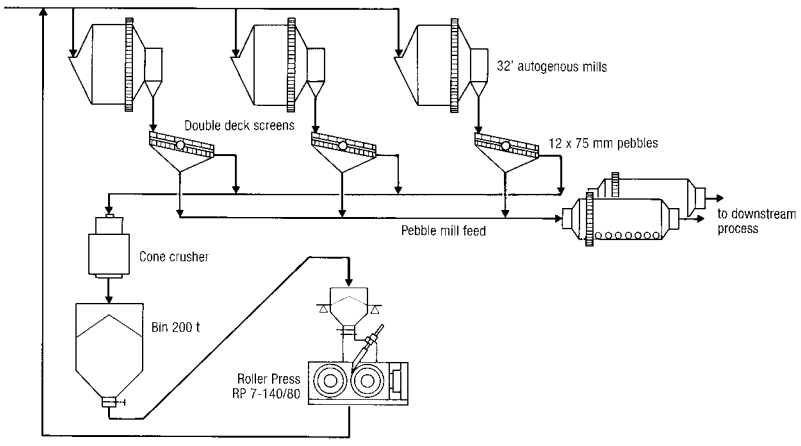
Company / location	Iron Dynamics Inc. | Butler, Indiana
Roll diameter	1,400 mm
Roll width	800 mm
Feed material	iron ore pellet feed
Feed moisture	1%
Feed size	2 mm
Final grain size	50% < 75mm
Throughput rate	400 t/h
Spec. energy consumption	< 1.75 kW h/t
Specific press force	5 N/mm² (max)
Motor size	2 x 670 kW
Lifetime of studded tyres	8,500 operating hours

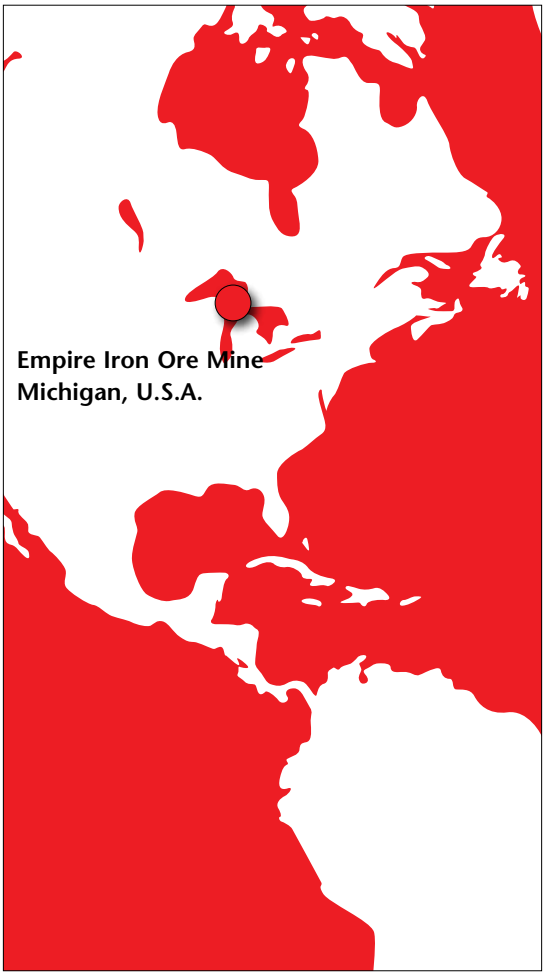


U.S.A.: HPGR 7 – 140 / 80 for crushing iron ore pebbles

U.S.A.: Design and process data

Company / location	Empire Iron Ore Mine | U.S.A.
Roll diameter	1,400 mm
Roll width	800 mm
Feed material	iron ore pebbles (pre-crushed)
Feed moisture	3%
Top feed size	63.5 mm
Final grain size	50% < 2.5 mm
Throughput rate	400 t/h
Specific energy consumption	< 1.7 kW h/t
Specific press force	5.1 N/mm²
Motor size	2 x 670 kW
Lifetime of studded tyres	17,000 operating hours

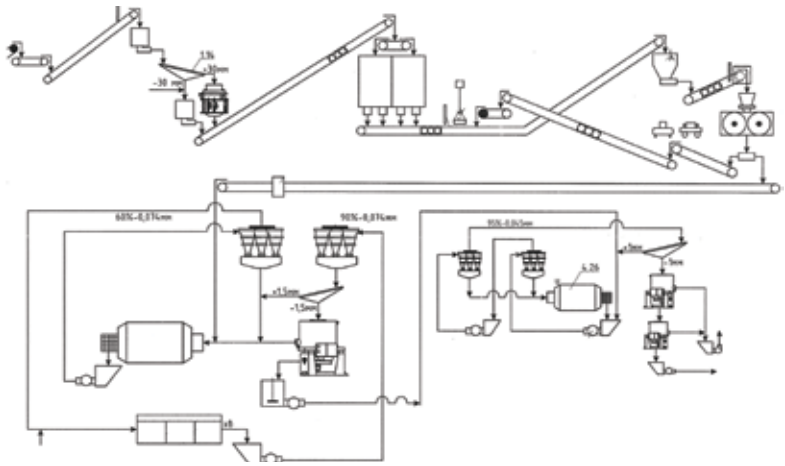




Kazakhstan: 2x HPGR 16 – 170/180 for grinding gold ore

Kazakhstan: Design and process data

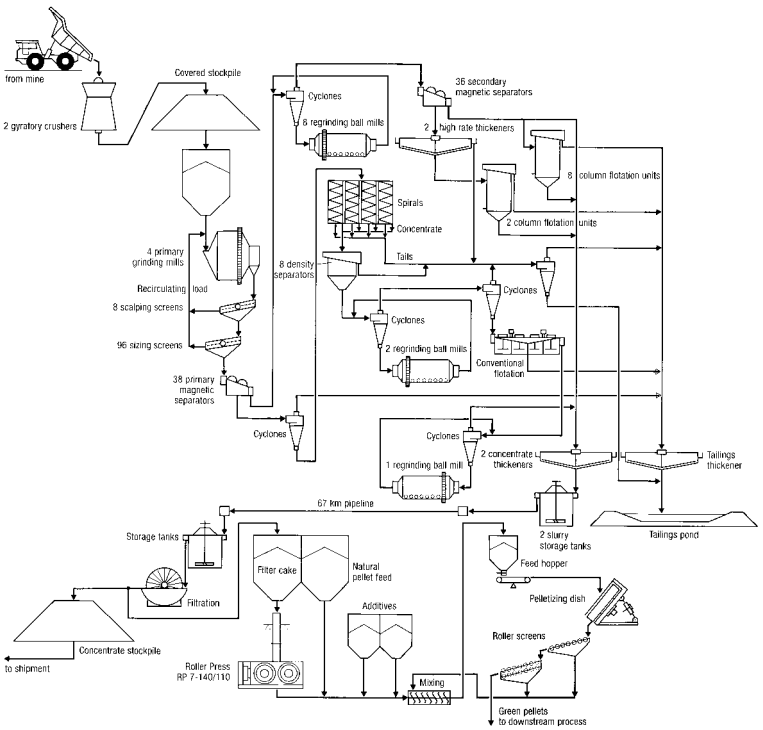
Company / location	Altyntau | Kazakhstan
Roll diameter	1,700 mm
Roll width	1,800 mm
Feed material	Gold ore
Feed moisture	max 5%
Top feed size	30 mm
Final grain size	P80 - 5mm
Throughput rate	1442 t/h
Spec. energy consumption	< 2.0 kW h/t
Specific press force	5 N/mm² (max)
Motor size	2 x 1,600 kW
Lifetime of studded tyres	8,500 operating hours

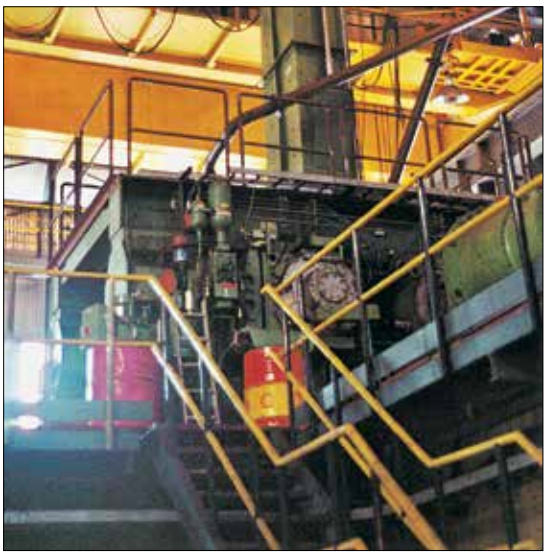


India: HPGR 7 – 140 / 110 for grinding iron ore pellet feed

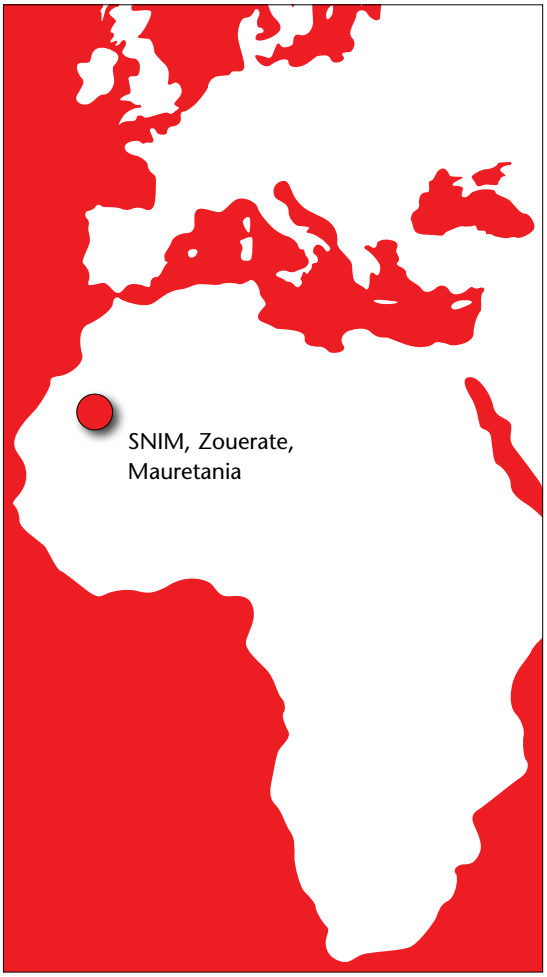
India: Design and process data

Company / location	Kudremukh Iron Ore Company Ltd
Roll diameter	1,400 mm
Roll width	1,100 mm
Feed material	iron ore pellet feed after ball mills
Feed moisture	9-11%
Feed size	1,300 - 1,600 Blaine (< 0.5mm)
Final grain size	1,600 - 2,150 Blaine
Throughput rate	530 t/h
Specific energy consumption	2.2 kW h/t
Specific press force	1.9 N/mm²
Motor size	2 x 660 kW
Lifetime of studded tyres	30,500 operating hours



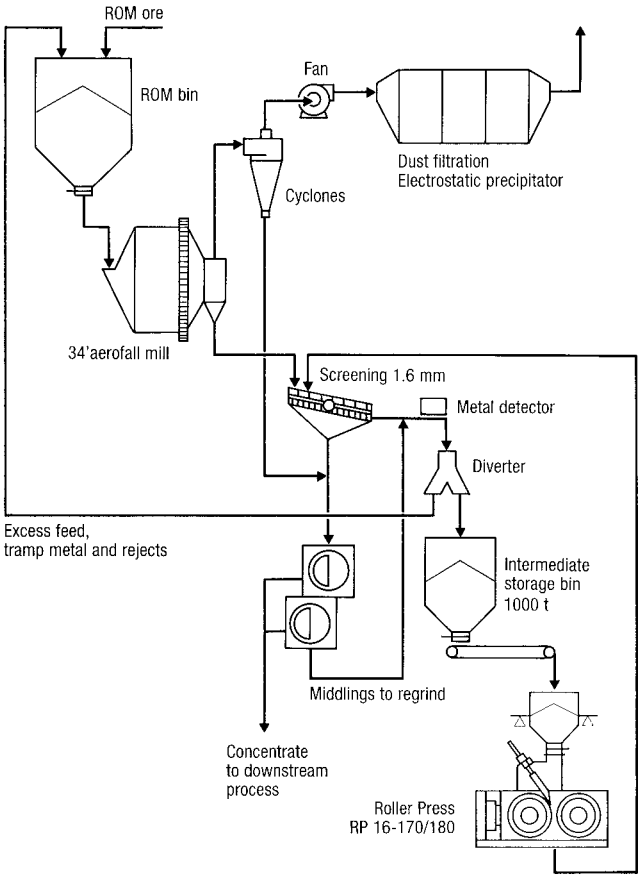


Mauritania: 2x HPGR 16 – 170 / 180 for comminution of iron ore



Mauritania: Design and process data

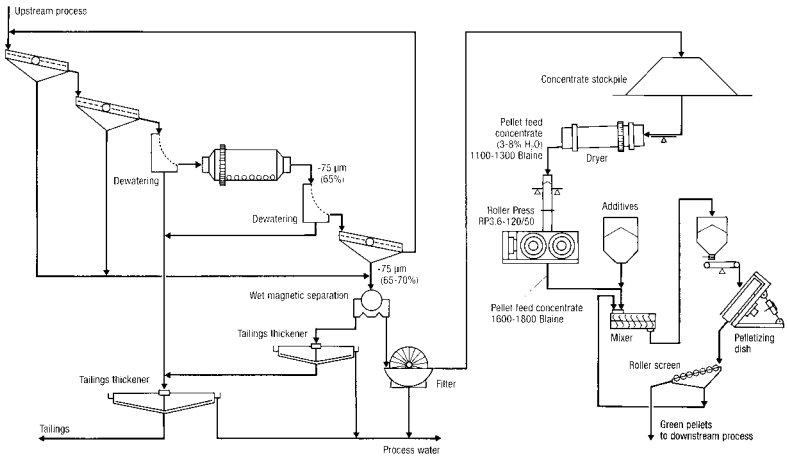
Company / location	SNIM | Zouerate, Mauritania
HPGR model	RP 16 - 170/180
Roll diameter	1,700 mm
Roll width	1,800 mm
Feed material	Coarse iron ore
Ball Mill Wi	11-15 kWh/t
Feed moisture	0-0.5%
Feed size	-20+1.6mm
Product size	65% < 1.6mm
Throughput rate	1,800 t/h
Energy consumption	< 1.0 kW h/t
Specific press force	2.7 N/mm² (max)
Motor size	2 x 900 kW
Lifetime of studded tyres	5,000 operating hours

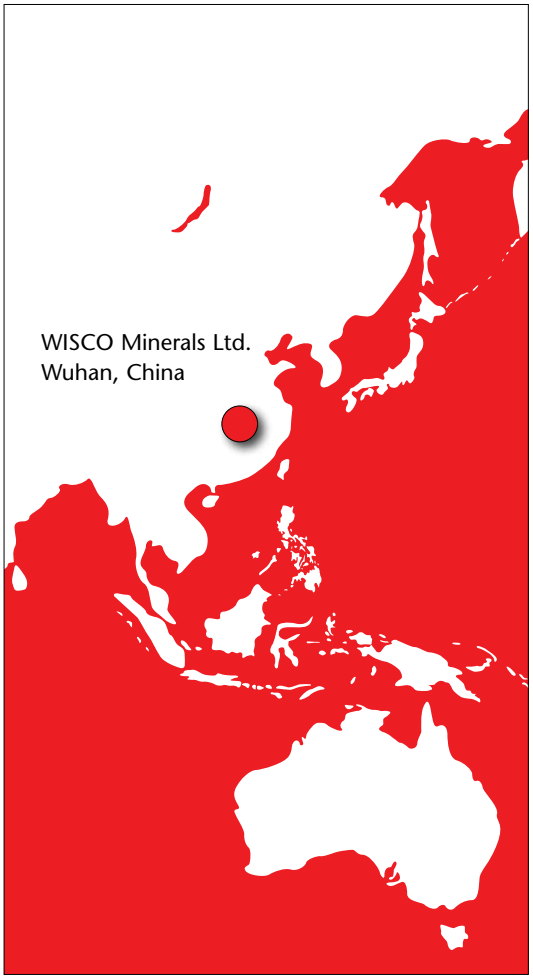


China: HPGR 3.6 – 120 / 50 for grinding iron ore pellet feed

China: Design and process data

Company / location	WISCO Minerals Ltd. | Wuhan, China
Roll diameter	1,200 mm
Roll width	500 mm
Feed material	iron ore pellet feed after ball mills
Feed moisture	3-8%
Feed size	1,100 - 1,300 Blaine
Final grain size	1,600 - 1,800 Blaine
Throughput rate	210 t/h (max)
Specific energy consumption	< 2.6 kW h/t
Specific press force	3.8 N/mm²
Motor size	2 x 355 kW

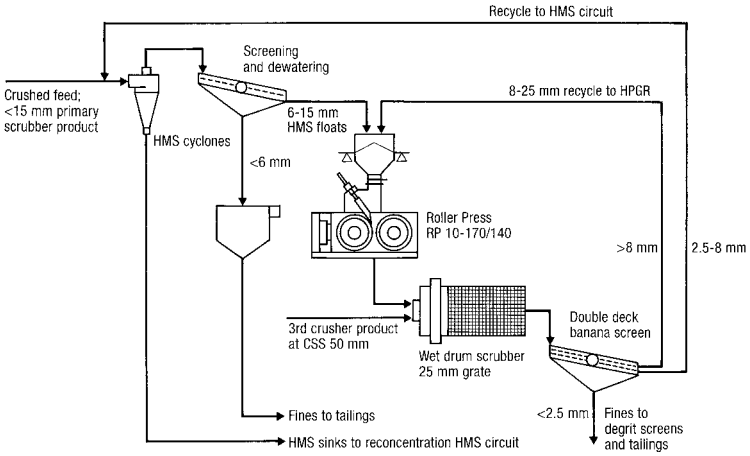




Australia: HPGR 10 – 170 / 140 for re-crushing kimberlite

Australia: Design and process data

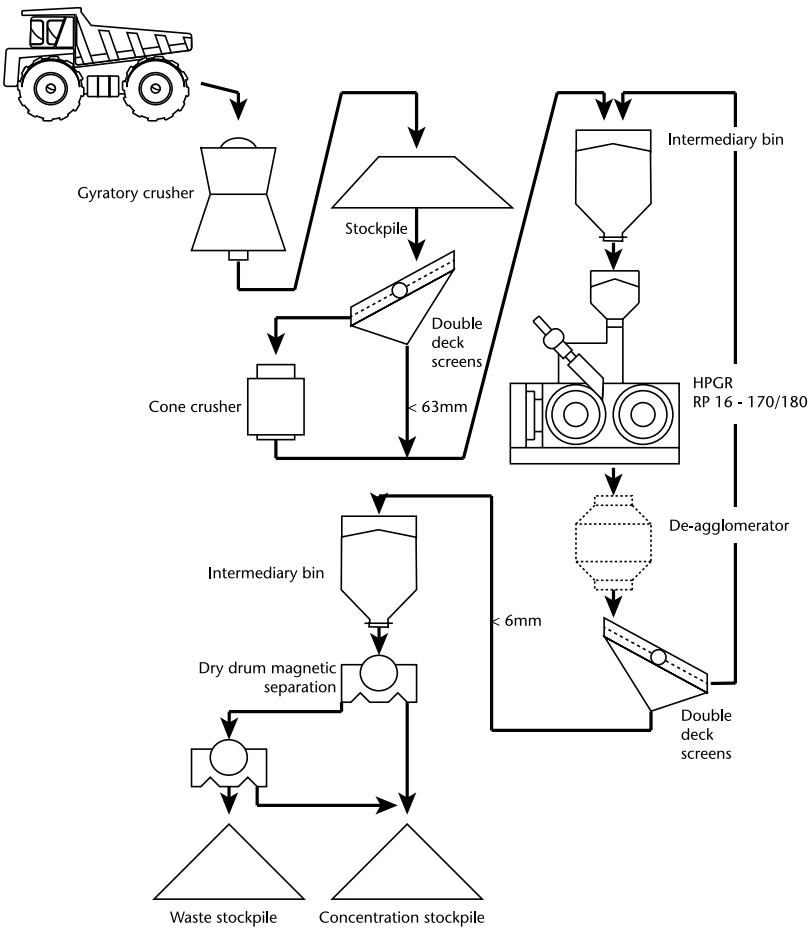
Company / location	Argyle Diamond Mines Pty Ltd.
Roll diameter	1,700 mm
Roll width	1,400 mm
Feed material	Kimberlite rock
Feed moisture	2-4%
Feed size	25 mm
Final grain size	39%
Throughput rate	800 t/h max.
Spec. energy consumption	1.75 kW h/t
Spec. press force	2.96 N/mm² (max 4.5)
Motor size	2 x 950 kW
Lifetime of studded tyres	4,000 operating hours (set 1+2) 6,350 operating hours (set 3) 7,000 operating hours (set 4)



Chile: HPGR 16 – 170 / 180 for grinding coarse iron ore

Chile: Design and process data

Company / location	CMH | Los Colorados, Chile
Roll diameter	1,700 mm
Roll width	1,800 mm
Feed material	Coarse iron ore
Feed moisture	< 3%
Feed size	0-63.5 mm
Final grain size	< 6.35 mm (55-75%)
Throughput rate	up to 2,000 t/h
Specific energy consumption	1.4kW h/t
Specific press force	3.2 N/mm²
Motor size	2 x 1,850 kW
Lifetime of studded tyres	14,600 operating hours



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Weir Minerals employs nearly 3,000 people worldwide. Our customers have direct access to the best engineering expertise supported by world-class management.

The design engineers and materials scientists, process specialists, project managers and manufacturing experts across Weir Minerals companies are among the best in the world.

To ensure that all our customers, wherever they are in the world, have access to local expertise of the very highest calibre, we are constantly sharing know-how and best practice in a culture of continuous improvement.

Our commitment of personal development enables individuals to fulfill their potential, and generates a passion for the business that is rare in an industrial manufacturing environment. By establishing a fast track leadership program, nominating product and process champions and creating cross-company, interdisciplinary project teams, we encourage a dynamic, flexible and innovative human resource.

Because of the nature of our close relationships, customers often depend on the mutual respect and understanding that is formed from strong professional, personal relationships. Weir Minerals is proud to recruit, retain and reward the ablest people from a wide range of industry sectors.

Product Portfolio

Weir Minerals has an advanced product range incorporating market leading brands covering virtually any application, in any environment.

We own a valuable portfolio of intellectual property, which is continually being extended through research and development in materials and fluid dynamics technology to enhance the wear life of our products. As a result, our global leadership in slurry pumps is combined with innovative designs in a complimentary product range of mill liners, hydrocyclones and slurry valves.

The Weir Minerals brands

WARMAN®
Centrifugal Slurry Pumps

GEHO®
PD Slurry Pumps

LINATEX®
Rubber Products

ENDURON®
Comminution Equipment

KHD*
High Pressure Grinding Rolls

VULCO®
Wear Resistant Linings

CAVEX®
Hydrocyclones

FLOWAY® PUMPS
Vertical Turbine Pumps

ISOGATE®
Slurry Valves

MULTIFLO®
Mine Dewatering Solutions

HAZLETON®
Specialty Slurry Pumps

LEWIS® PUMPS
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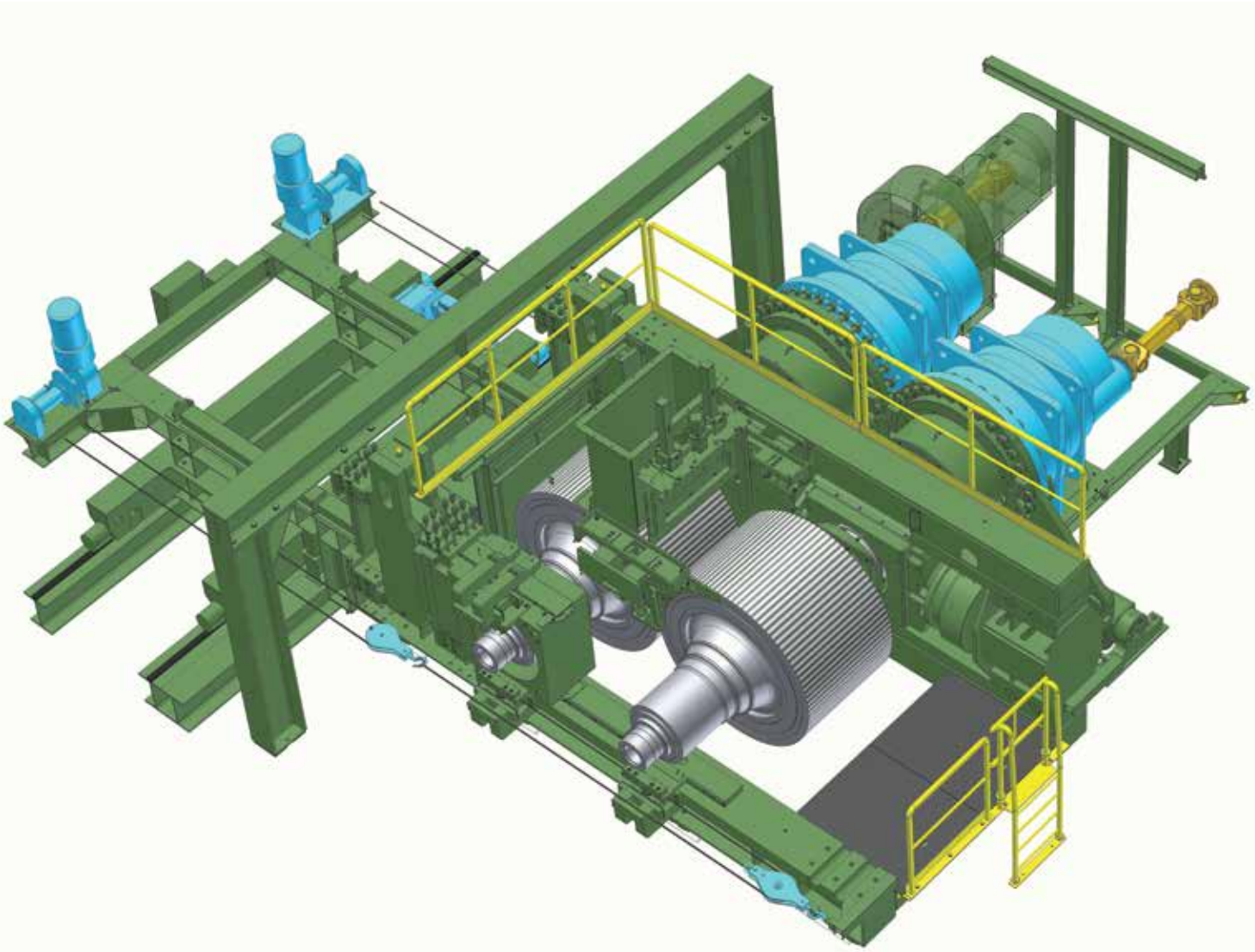

KHD*
High Pressure Grinding Rolls

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