With over 100 years experience in grinding technology, Outotec is one of the largest mill suppliers in the world. Outotec’s dedicated team of grinding specialists provide design engineering, testing and analysis in order to select the mill best suited to the individual requirements of the customer.

Benefits
- Performance
- Safety
- Reliability
- State-of-the art technology
- Efficient design and operation
- Easy operation and maintenance
- Truly customized designs
The key to successful concentration

Solid grinding experience

Outotec has extensive expertise in minerals processing, encompassing comminution, separation, concentration, dewatering and automation and is able to provide a comprehensive range of advanced technologies for each process stage. Outotec can supply both single units of equipment or turnkey deliveries if required.

Outotec’s grinding technologies are backed by a history of over 100 years of experience in the industry, from Morgadshammar, Scanmec and Nordberg Mills, which today are unified under the global Outotec name. Outotec’s state of the art designs are a result of years of development; yesterday’s practical experience meets today’s technological advancements to produce premium equipment. Outotec’s grinding mill range includes semi-autogenous (SAG) mills, autogenous (AG) mills, ball mills, pebble mills, scrubbers, rod mills, High Intensity Grinding (HIG) mills and High Pressure Grinding Rolls (HPGR). Outotec specializes in providing mills which are customized to the individual requirements of each project, resulting in maximized performance and reliability.

Optimum mill type and size

Correct mill sizing requires extensive experience in comminution and beneficiation processes and Outotec’s dedicated mills team includes recognized experts in these fields. A sound understanding of parameters such as the Bond Indexes, VCS, SAG design or JK/SMK parameters together with feed and product size distribution is necessary to optimize mill sizing and design for specific applications. Using Outotec’s combined expertise in grinding, in-house sizing programs and grinding database, Outotec is able to accurately determine the correct mill type and size for any given application. A thorough understanding of the material to be processed is essential for the successful design and operation of any mill.

Ore testing for that extra edge

Outotec has test facilities for material mineralogy and liberation analysis, as well as complete minerals processing facilities at our own R&D center. In the instance that additional data is required, the customer can rely on Outotec’s close relationships with some of the foremost test centers around the world.
Ø28 Ball Mill
-14,000 kW installed power
A full range of mills for wet and dry grinding

The demands of hard rock mining and industrial minerals operations require a diverse range of grinding mills for both wet and dry applications. AG and SAG mills are currently the industry standard for primary milling and Outotec provides both high aspect or low aspect AG and SAG mills to suit any application across the full size and power range.

**HPGR**

High Pressure Grinding Rolls are used in primary comminution. Outotec HPGR solutions are energy efficient technology packages for comminution circuits that enable processing of harder ores.

**AG and SAG mills**

Autogenous and semi-autogenous mills are designed for grinding or primary crushed ore and are the most widely used in concentrators globally.

**Ball mills**

Ball mills are typically used for secondary and/or tertiary grinding to prepare the material for downstream concentration processes.

**Rod mills**

Rod mills are mainly used for primary grinding of crushed ore with a particle size range up to 50 mm for soft materials and between 20 and 30 mm for harder materials where a narrow product size distribution is required (e.g. for subsequent gravity separation).

**Pebble mills**

Pebble mills are typically used for secondary grinding, where it is important to minimize processed mineral contamination and where the ore has a tendency to form scrubbers. The application range is similar to that of ball mills.

---

**Scrubbers**

Scrubbers operate in many applications where the feed material has high clay content and where ore washing is required. Typical applications include washing of laterites prior to leaching and removal of clay from hard rock ores prior to crushing.

**High Intensity Grinding**

Typical applications for the HIGmills are regrinding of concentrates e.g. magnetic, flotation. Outotec HIGmills™ provide an advanced, energy efficient, fine and ultra fine grinding solution utilizing existing, well proven technology.

---

[IMEasurements for Shell-supported Ø20' SAG mill operating in Mexico.]

[IMEasurements for Trunnion supported Ø20' Ball mill in Australia.]
Robust design

Outotec mills are designed to produce optimal results, even in harsh environments. Outotec offers both trunnion and shell supported mill design, complemented by a drive solution tailored for optimum performance in any environment.

Mill bearings

The type of support bearing is selected on the basis of mill size, intended duty and environmental conditions at the installation site. Outotec offers mills supported on a variety of bearing arrangements: hydrodynamic and hydrostatic journal, spherical roller, hydrodynamic and hydrostatic multi-pad bearings.

Mill support bearings – Journal bearings

Sleeve bearings in Outotec’s trunnion-supported mills are hydrostatically lubricated during start-up and stopping and can be hydrodynamically and/or hydrostatically lubricated during operation. The journals are easily removable and bearings for both ends of the mill are identical and reversible. Small reservoirs, integral to the bearings, provide sufficient oil for the mill to be safely stopped in the event of a power failure.

The bearing sleeve material is either bonded white metal or centrifugally cast bronze. The bearing sleeve supports the lower 120° of trunnion journal surface. Swivel support allows the bearing sleeves to self-align as mill loading changes. The housings (base and cap) are machined from steel plate.

Outotec offers both hydrodynamic and hydrostatic multi-pad bearing arrangements. In hydrodynamic applications the pads are machined from high-strength steel and fitted with a white metal bearing surface specially designed to suit the trunnion or shell diameter. As with the hydrodynamic sleeve bearings, high-pressure oil is delivered to the center of each pad to lift the mill for start-up and low pressure oil is delivered to a slot at the ends of each pad to provide hydrodynamic lubrication for operation.

Outotec’s hydrostatic multi-pad arrangement provides market leading lubrication as well as load sharing between bearings to ensure consistent loading of the journal surface. They allow for compact mill design and can be applied to any bearing journal diameter. This bearing technology was originally developed during the 1970s in conjunction with SKF. In 2008 the bearing technology was fully acquired by Outotec and has since been the subject of continued improvement by Outotec’s engineering team.

The hydrostatic bearing pads are arranged in a fabricated housing which includes a flat-bottomed base plate for easy foundation construction. Two or four pads can be used at each end of the mill depending on the loading and mill geometry. The two-pad arrangement gives automatic load sharing during operation while four pad arrangements are provided with hydraulic cylinders to ensure load is evenly distributed between each pad.

Jacking cylinders capable of lifting one end of a fully loaded mill are installed integral within each bearing housing to allow for rapid erection and maintenance. Locking collars are provided with the hydraulic jacks to ensure safety during maintenance operations.
Trunnion-supported mills

Trunnion support is the most common way of supporting a mill in a minerals processing application, especially very large mills that would otherwise need a split in the journal surface to accommodate shipping restrictions. Trunnion journals have a high consistent stiffness which is a critical property for any bearing journal. The relatively small bearing diameter and stiff journal surface facilitates the formation of an excellent lubricant film distribution.

Outotec trunnion-supported mills can use any of the bearing types described previously, however most mills are supplied with hydrostatic multi-pad bearings.

The hydrostatic multi-pad bearing arrangement results in a mill with very low resistance to rotation, providing energy savings over alternative designs. A thrust surface is part of the fixed end journal and special hydrostatically lubricated shoes are used to resist the axial thrust of the mill-rotating assembly.

Shell-supported mills

Outotec’s shell-supported mills are more compact, occupy less floor space and require simpler foundations than comparable trunnion-supported mills. This is an important advantage, especially for indoor installations in severe climates and offers considerable cost savings. Shell-supported mills are supported by bearings mounted directly to the shell, thereby yielding substantial advantages. Because the end plates of the mill do not support the structure, the feed and discharge openings may be sized to meet process conditions without being constrained by trunnion bearing limitations.

Outotec shell-supported mills use multi-pad bearings, where the journal surface is machined into the specially reinforced end sections of the shell structure. The thrust bearing design is similar to a trunnion supported mill but rather mounted on the mill periphery alongside the journal for the multipad bearings. The ring gear on shell-supported mills is normally mounted onto a flange, centrally located on the mill shell, away from the ends. This enables the remaining components of
the mill drive train to be brought closer to the mill, which in turn allows for smaller foundations and lower installation costs.

**Mill drives**

Most mills are driven by ring gears, with a 360° fully enclosing guard. The ring gear casting material is either nodular iron, cast- or forged steel. These gears are usually designed with helical type teeth to make them reversible, allowing the use of both flanks throughout their operational life. The drive may be mounted at either the feed or the discharge end of the mill. Whilst mills rated up to 10,000 kW can be driven by a single pinion, dual pinions are mostly used for mill applications above 6,000 kW.

Both high-speed induction type or low-speed synchronous type drive motors are available. High-speed motors require an intermediate gearbox. Smaller mills up to 750 kW are also available in a trunnion-driven arrangement. Large mills exceeding 17,000 kW normally use gearless drives.

**High Pressure Grinding Rolls**

Outotec’s high pressure grinding rolls are designed and manufactured by Köppern, which has over 100 years of experience in HPGR R&D, testing and manufacturing. The HPGR comminution process is based on the introduction of coarse feed material into the preset gap between two counter-rotating rolls; a fixed roller and a floating roller. The fixed roller is supported by the press frame and the floating roller by hydraulic and pneumatic systems. During high pressure comminution, the feed material is exposed to high pressures that crush and fracture the densest of materials. Due to the relatively uniform loading of the material in the compression zone, the very short retention time of the material in the HPGR and the minimal energy required to transport material in the press, the process requires less energy input compared with conventional crushers and mills.

**Outotec HIGmill for ultra fine grinding**

The HIGmill comprises a mill body, shaft with grinding discs, shell mounted counter rings, gearbox and drive. The grinding chamber is filled up to 70% with grinding beads. Rotating discs stir the charge and grinding takes place between beads by attrition. The number of discs (grinding stages) depend on the application and can be up to 30. Feed slurry is pumped into the mill via bottom connection. When the flow transfers upwards, it passes all consecutive grinding stages. Final product discharges at open atmosphere at the top of the machine.

Because of the tall, narrow, vertical mill body arrangement, grinding media is evenly distributed and mineral particles remain in constant contact, significantly increasing grinding efficiency.
Outotec's market leading lubrication systems are specifically designed to provide high quality lubrication of the mill components whilst being safe and easy to maintain. In recent times, Outotec has invested in new lubrication systems that allow the continuous reuse of lubricants where traditionally grease was used. For example, Outotec now produces ring gear lubrication systems that use oil circulating within a conditioned closed loop.

Outotec has also designed a proprietary sealing arrangement, called the Barricade seal, to enclose large diameter interfaces, such as around bearing housings and ring gears. The Barricade seal arrangement is innovative in that it runs against a replaceable seal plate avoiding the wear on critical mill components known to occur in other sealing designs.

Outotec offers a complete range of mill linings suitable for various process conditions. Lining materials include cast steel, cast iron, solid rubber, rubber-steel composites or ceramics. Wave or lifter bar linings can be supplied, depending on the application.

For primary mills, a feed chute incorporating a "rock box" is usually provided. Large feed chutes are typically supplied on wheeled carriages, which roll back away from the mill or roll away laterally on tracks, to provide access for mill inspection and liner replacement. Ball, rod and pebble mills are often supplied with spout feeders and replaceable liners supported by a wheel-carried steel structure. Other available feed arrangements include screw-type, vibrating drum and scoop-type feeders.
Discharge arrangement

Outotec provides a wide variety of discharge arrangements, such as overflow, peripheral, grate and open-ended.

SAG and AG mills typically have grate discharge arrangements which can be either with or without trommel screens. SAG and AG mills with open-ended discharge arrangements are usually more efficient than grate discharge arrangements. However, as an alternative to an open ended discharge arrangement Outotec offers the patented Turbo Pulp Lifter® (TPL) for suitable applications.

Turbo Pulp Lifter (TPL)

TPL is a revolutionary pulp lifter design that reduces back flow through the grate to minimize slurry pooling and avoid pebble carryover in mills that do not have an open end. Dramatic reductions in power consumption and improvements in process stability have been observed when TPL has been installed. More information on TPL can be found on the Outotec website.

Scrubber, ball, rod and pebble mills typically have overflow or grate discharge arrangements with trommel screens. Generally, peripheral and open-ended discharge arrangements are only used to meet unique process requirements.

Technically complex applications

Outotec has an established reputation within the industry for producing customized mill solutions for exotic applications. Outotec has supplied the world’s largest stainless steel mills in both explosion clad and solid form. These mills are used to grind slurries with a pH of less than one, which creates an aggressive milling environment.

Quality assured

Outotec mills meet the highest quality standards for design, manufacture and supply. Regional business centers are either in pursuit of, or have already received, ISO 9001 certification. Once a contract is awarded, a quality assurance plan is raised in the regional Outotec Grinding office. This plan outlines the critical steps in the design and production process, and lists the applicable documentation and physical inspections for each step.
Total solution

Advanced mill design analysis

Outotec mills are designed using the latest 3D computer-aided design (CAD) and drafting techniques. Designs are fully verified with the latest finite element analysis (FEA) tools and techniques, which predict peak stress levels in the mill structure and the ultimate life of the mill’s structural elements.

Torsional analysis of the drive train can also be conducted, ensuring the mill operates at speeds away from harmonic frequencies. For mills utilizing hydrostatic or pad type bearings, Outotec’s lubrication design analysis predicts the minimum thickness of the bearing fluid oil film.

Experienced engineers

Outotec has designated mill teams located in Europe, the Americas, Australia and South Africa. Outotec’s design and application engineers are recognized industry leaders in grinding and comminution.

Continuous improvement

Outotec strives to be the leading supplier of comminution technology worldwide. Outotec utilizes feedback provided by own extensive service and user networks to continuously improve products and services.

Energy-efficient, cost-effective technologies

The selection of an appropriate mill configuration depends on the feed size distribution, the desired product size distribution and other physical properties which define the relative hardness, integrity and abrasiveness of the material. By applying our cutting-edge technology and solutions, you contribute to energy savings and environmental protection.

Outotec aims to optimize the customer’s initial investment costs as well as the life-time operational costs. Therefore, effectively balancing capital and operating costs requires an experienced, practical understanding of efficient energy and optimum mill life-span configuration.
Worldwide service and support

To ensure premium quality product service and support, Outotec mills are backed by Outotec’s worldwide sales and service network. Outotec specialists ensure that the mill is properly installed prior to commissioning and the process performance is verified after commissioning.

World-class grinding mill and crusher management

Outotec offers additional value-added services and world-class technologies over the complete lifecycle of the comminution circuit. Outotec has expertise in wear monitoring, asset management and performance optimization. MillMapper and CrusherMapper are the first technologies in the world which measure, model and manage liners in grinding mills and crushers.

After commissioning, Outotec local office provides:

- Ongoing support with promptly delivered replacement parts
- Other mechanical services, including complete mill reconditioning
- Complete process evaluations and performance diagnostics
- Liner wear measurements and profile development
- Maintenance inspections
- Alignment checks
- Gear reversals
- Service contracts

Outotec can tailor services efficiently to customer specific needs, when considering the necessary operational and maintenance services already from the beginning of the project.

As a trusted service partner, Outotec ensures an optimized operation for the entire lifetime of our customers’ plants.

Obtaining all spare parts and maintenance as well as process and equipment design from the same organization ensures that the plant runs optimally. We make sure that our customers receive only the highest quality parts, consumables and upgrades that can be seamlessly integrated into the plant.

Benefits of Outotec Service:

- Critical original spare parts in stock
- Process and equipment know-how
- Minimized downtime and unscheduled stoppages
- Maximum operating performance

Outotec works in close cooperation with its global network of experienced, qualified sub-suppliers to produce the mill’s main components as close as possible to the installation site.

Engineers from Outotec international mill business centers perform progress inspections to verify compliance with applicable specifications and standards. The results are recorded and form a part of the mill installation record, which is maintained for the life of the installation.

Outotec service experts provide punctual spare parts logistics, maintenance and training, as well as assessment and consulting services that generate a competitive advantage.
Outotec provides leading technologies and services for the sustainable use of Earth’s natural resources. As the global leader in minerals and metals processing technology, Outotec has developed many breakthrough technologies over the decades. The company also provides innovative solutions for industrial water treatment, the utilization of alternative energy sources and the chemical industry. Outotec shares are listed on NASDAQ OMX Helsinki.