SIEMENS Gearless Mill Drives
New standards for productivity
Your challenge:
High availability, lower costs, better performance

Grinding represents a crucial process step in ore processing – for the overall performance of a mine. That’s why the gearless drive of a grinding mill is the crucial piece of equipment in the concentrator – and why it is subject to very high demands. High availability and reliability throughout the entire lifecycle are a must, while unplanned downtimes need to be minimized by proven design and skillful planning of the maintenance.

Operating expenditures also need to be kept down to ensure economic viability and competitiveness. Energy consumption accounts for the major operating costs, which means that the solution needs to consider low energy consumption and the flexibility to adapt to production volumes as well as to ore characteristics.

You expect...
- Operational reliability
- High productivity
- Lower operating costs
- Minimized downtime
- Comprehensive service
Our solution:
SIMINE Gearless Mill Drives – outstanding reliability at your hand

The Gearless Concept
The Gearless Drive avoids any contact between the rotating mill and the static parts of the motor. This enables a continuous workflow without maintenance on the gears or the pinions. What used to be downtime is now productive time.

Vibration-free, low-weight, short-circuit-proof design with high stiffness
Designing highly complex capital goods such as a Gearless Drive means starting with a perfect concept. Especially for motors, Siemens offers a minimum-weight, short-circuit-proof design featuring maximum stiffness. This is why the resonance frequency of the motor is considerably higher than the operating frequencies.

Reliability and availability
The extremely high reliability and availability of Siemens SIMINE Gearless Mill Drives is based on mature technology, which we continually update with new, proven features. Cycloconverters, for example, are just one of the reasons why Siemens solutions excel. Their decisive advantage over other products on the market? They are fuseless and short-circuit-proof. And thanks to innovative software solutions, short power breaks can be bridged without interrupting operation of the SIMINE Gearless Mill Drives.

Longer service intervals thanks to low-wear Drive processes
The SIMINE Gearless Mill Drives rpms can be adapted to your operations at any time, and are infinitely variable and uncomplicated. Whether manually or fully automatic – rpms can be adjusted to the properties of the ore, resulting in significantly less wear to the mill lining. The mill’s direction of rotation can be changed simply with a switch, so that the wear on the liner is distributed equally from both sides.

Shorter maintenance time for mills
Simple control of the inching and creeping modes lets you quickly set up mill maintenance procedures without endangering the safety of the staff. When the SIMINE Gearless Mill Drives is in inching mode, one rotation of the mill is all you need. The mill will achieve the exact angle that was preset by the operator, and it is not necessary to repeat the procedure. At the end of the inching operation, the SIMINE Gearless Mill Drives stops the mill with balanced charge, and with no time-wasting oscillations. During creeping mode with 0.3 rpm, the operator can directly control the mill while observing the mill and the material. Whether inching or creeping, you can dramatically shorten the mill’s maintenance times, and thereby significantly boost availability and mill productivity.
Good reasons for
SIMINE Gearless Mill Drives

- **Operational reliability**
  through the less vulnerable gearless concept and a vibration-free, sophisticated design with proven track record that reduces unplanned downtimes to a minimum

- **Lower costs**
  through optimized electrical efficiency and reduced wear

- **Comprehensive service**
  with a multitude of features that help keep your mill up and running

- **Minimized downtime**
  through dedicated maintenance modes such as creeping or inching with rollback of mill

- **High productivity**
  due to outstanding availability and the highest reliability in the market
Comprehensive services

**Online monitoring**
Find out instantly how the mill and Gearless Drives are operating. Monitor operations from any plant office, maintenance office, management office, the Siemens office, or from any connection that allows online Ethernet communication.

**Fault analysis**
For quick and efficient fault analysis, our reliable diagnostic system includes transparent fault documentation (using the WinCC visualization system), as well as a high-speed data recorder that displays all procedures involving electrical variables.

**Maintenance by Siemens**
Siemens has service engineers in the major mining countries who are trained in Gearless Drive technology. Siemens offers maintenance contracts tailored to your specifications. The main types are preventive maintenance with on-call service and performance-based maintenance contracts.

**Remote service**
The user’s local maintenance personnel or Siemens’ maintenance personnel are assisted by the experts at the factory who provide remote diagnostics via online Ethernet communication, recommendation-based troubleshooting, direct fault diagnostics and downloading, and the installation of software while the machine is operating.
More than 30 years of experience in reliability

Control principle
The substantial demands on the operating performance of mill drives require a powerful control system. Excellent performance characteristics can be obtained by applying the TRANSVEKTOR® control. The control principle as shown above is based on orienting the phase angle of the stator current in accordance with the angle of the effective flux. To calculate flux conditions, the motor is simulated by two mutually supplementary models, thereby permitting the machine currents to be injected optimally at any time over the whole speed and load ranges. This means that the synchronous machine, as seen from the speed control system, behaves like a DC machine.

The TRANSVEKTOR control used on high-power mill drives has gone through a long development phase, and during the last 33 years, a lot of experience has been gained. The first Gearless Drive has been operating successfully with this control for more than 30 years. A phase of continuous improvement and further development followed the initial introduction. Today, the TRANSVEKTOR control is entirely digital, resulting in a relatively small number of different hardware modules, absolute reproducibility of settings and substantially improved diagnostics for easy troubleshooting.

Filter and compensation
The need for filter and/or compensation equipment is not a given issue for a Gearless Drive system. A harmonic study individually determines whether or not the particular plant configuration and network need harmonic filtering. As the Drive concept is a 12-pulse system, only the 11th and the 12th harmonics with their related sidebands have to be looked at. Harmonics with higher harmonic order exist, but their magnitude is negligible. The starting point is to develop a complete plant single line with all users and their respective loads and to get complete information about the network. This, together with the given restrictions either from the relevant code or from the responsible power company, allow a harmonic study to be performed. The results of the study determine the need for filtering. If filtering is necessary, the compensation of the power factory is taken into account.
Sophisticated design – from engine to project management

Whether you’re talking about SAG or ball mill, space is a sensitive subject, especially in the concentrator. That’s why we always design our SIMINE MILL Gearless Drives to combine maximum performance with limited space requirements.

Suitable foundation and adequate ground conditions
Since our solutions have a low motor weight, this noticeably reduces the demands on the foundation and ground conditions. The layout needed for the buildings and the installation cranes is therefore simpler than that required by others.

Open-air installation
The outdoor version of the SIMINE Gearless Mill Drives has been successfully in operation since 1998. The design of the outdoor version takes into account the tough ambient conditions as well as the absorption of solar radiation. The sealing system of the SIMINE Gearless Mill Drives is a proven design incorporating extremely low maintenance with ingress protection that is rated at IP 55, and complemented by a purpose-built rain shield. The outdoor version of the SIMINE Gearless Mill Drives allows omitting the concentrator building, a considerable saving of investment capital.
Optimal project development
Special attention is paid to the Siemens project management in order to achieve: the optimum project development; the milestones of the client’s project schedule; perfect coordination with other suppliers of equipment and services; the minimum start-up time; rapid attainment of production; maximum uptime, and the specific quality objectives. Siemens designates an experienced engineer as the project manager, who is the contact for the customer and therefore the focal point when it comes to the Siemens resources that are necessary for the project. The key responsibility of the project management is to lead and coordinate Siemens’ project activities throughout the project in accordance with the client’s schedule. A main factor in meeting these objectives is transparency for the client and the active involvement of the customer’s personnel.

Clearly defined interfaces
The project manager is also responsible for ensuring that all activities are properly coordinated with the activities of others involved in the project, e.g., mill supplier, civil engineer, installation contractor and the client’s consultant engineer. All interfaces to others are defined and clarified in a very early stage of the project and documented in drawings for approval for the client. The clarification of the mill-motor interface is a multifaceted task, a procedure which has been repeated successfully many times in the past.

Siemens Industry Sector and our subsuppliers have earned the Quality Systems Certificate for the Standard ISO 9000 and have implemented the quality systems according to ISO 9001.
The direct path to more productivity: Operational reliability

Electrical equipment and automation of a Drive system
At the heart of every grinding section are the larger grinding mills. The stringent demands for high throughput, highest availability, optimized grinding circuits and power consumption optimization require high-performance electrical equipment in addition to the technological and mechanical prerequisites. Besides the conventional equipment, which consists essentially of the energy supply and power section of the Gearless Drive and the associated auxiliaries, increasing importance is being attached to plant automation and diagnostic systems.

Short-circuit-proof cycloconverter
The synchronous machine is fed by a cycloconverter (CCV). This cycloconverter transforms the three-phase system of the line with fixed frequency to the variable frequency of the motor. The output voltage of the converter consists of parts of the line voltage which, when arranged in series, produce a sinus curve.

A number of measures taken in the closed-loop control system make it possible to use a cycloconverter of this simple configuration and yet achieve an excellent torque variation with negligible harmonics. The harmonics produced in the torque are significantly below 2 %. This satisfies the requirements of all grinding motors. The reversible converters are operated without circulating current, thus leading to a relatively simple design of the power selection and low reactive-power demand. Siemens’ cycloconverter is fuseless and short-circuit-proof.

Its thyristors are designed to disconnect the short circuit. The benefit to you is that if this type of failure occurs, no replacement of fuses or other components is required.

Short-circuit-proof motors
As it is not possible to completely avoid short circuits in electrical systems, all electrical standards require that electrical equipment is resistant to the high forces resulting from short-circuit currents. The SIMINE Gearless Mill Gearless Drives has proven its resistance to short-circuit forces in several events. High absorbability and damping attributes are required to resist abnormal operation conditions such as those which result from short-circuit forces.

The high absorbability and damping characteristics are achieved through activities in two fields:

- Electrical damping results from the parallel connection of coils in the stator windings. The unbalanced magnetic pull, which causes vertical and primarily horizontal forces on the stator fixation and on the mill body, is damped by equalizing currents in the stator winding. To engender equalizing currents, the stator winding consists of several parallel paths by means of a multiturn coil winding. Each slot is equipped with 16 conductors, eight of them connected in parallel. Single-turn coil windings (bar windings) are normally connected in series, hence equalizing currents are not possible.
Mechanical absorbability results from the design of the stator structure and from the material selected. The especially designed stator structure and its weight reduce the transfer of short-circuit forces to the foundation.
A massive and inflexible stator block of high weight would transfer the short-circuit force directly to the foundation with high stresses on the stator fixation and on the foundation itself.

The motor of the Gearless Drive provides the optimum solution between damping attributes and high stiffness. High stiffness together with low weight is required for high resonance frequencies in order to prevent vibrations.

**Stiffness and vibration analysis**

Every mechanical system must undergo stiffness and vibration analysis. For the Gearless Drive system, this verification is more complex because the rotor is an integral part of the mill body and the motor has no bearings of its own. These calculations have to take into account the complete system, consisting of motor, mill and foundation, in order to ensure an optimized system. The calculations therefore must be conducted jointly between mill supplier, motor manufacturer and a civil foundation engineer.

In design and examination, Siemens applies the highly sophisticated FEM model. The FEM model considers the mechanical relations as well as nonlinear electrical equations and deflection as a function of location, without blowing the safety factors out of all proportion.

The highly sophisticated FEM model was developed based on experience with the Cadia ring motor. In the design of large structures, such as the stator of a Gearless Drive, high stiffness is required in order to increase the values of resonance frequencies and resonance modes.

There are therefore many reasons why low weight is advantageous:
- For installation, because cranes must move the stator segments
- For concentrator building design, because the overhead traveling crane must be supported by the building structure
- For foundation design, because it reduces foundation costs
- To increase resonance frequencies, because the value of resonance frequency is reciprocal to the weight

Instead of a heavyweight solid structure, Siemens has equipped the stator structure with attributes that are designed to attenuate extreme forces caused by possible short circuits. Siemens’ highly sophisticated FEM model allows you to find the optimum design for Gearless Drive motors with the highest stiffness and lowest possible weight.
Enhanced control for an improved operation – inching, creeping, succeeding

Easy operation
A simple control panel based on a highly sophisticated system helps the operator handle the mill by simply pressing a few buttons. The design facilitates the mill’s operation and reduces maintenance. Normal operation is implemented from the local control panel or remotely from the central control room. Each normal stop ends with a balanced charge of the mill, preventing any subsequent oscillation of the mill. Change of rotation direction is initiated by turning a switch during standstill.

Inching
Inching is fast and ends with the balanced charge of the mill, and no subsequent oscillations. The maintenance operator at the local control panel selects the required angle. The SIMINE Gearless Mill Drives accelerates the mill to 1 rpm. While the mill is starting, the turning angle with the maximum required torque (when the charge starts to cascade) is stored together with the measured torque value itself. Using these values, the closed-loop control automatically calculates the angle that’s required to balance the mill during the stop procedure. The SIMINE Gearless Mill Drives turns the mill to the requested angle indicated on the local control panel, and it overturns it by that calculated angle which is required to balance the mill. Then it automatically changes the direction of rotation and turns the mill back to the requested angle, stopping with a balanced charge. The brake applies automatically.

Creeping
Creeping at 0.3 rpm is useful for slow movements, which the maintenance operator can observe directly, in order to trim the mill precisely to a certain position. The portable creeping panel allows for the operation of the mill, e.g., standing at the feed side and looking inside the mill (with chute removed). This enables the operator to turn the mill exactly into a position where the requested liner just leaves the material.

With the portable creeping panel, the operator can move freely around the mill, and is able to observe the mill from different places. Pushing the “Run” button on the creeping panel starts the motor turning the mill slowly with 0.3 rpm in the direction selected on the local control panel. The SIMINE Gearless Mill Drives lifts the charge. The operator most likely will wait until the charge cascades. When the operator wants to stop the mill, he releases the push button, and the SIMINE Gearless Mill Drives holds the load, applies the brake and the charge remains in unbalanced position. From this unbalanced position the operator can continue turning the mill by pushing the “Run” button.

There is no waiting time. Nor is any additional operation needed to balance the mill’s charge. Maintenance personnel can safely enter the mill on an even surface without risk of moving material.

Creeping procedure
The SIMINE Gearless Mill Drives now starts the mill directly from this unbalanced position. This mode allows inspection of different points on the mill shell or inside the mill quickly one after the other without the need to balance the mill in between. The operator can even change the direction of rotation at the local control panel and let the mill turn in the other direction.

**Balancing**

If the mill needs to be balanced out of any position, the operator can simply switch over to balancing mode and start the mill. This makes the Gearless Drive balance the mill without any oscillations to allow the maintenance crew immediate and safe access. The procedures of inching and creeping and their easy handling considerably reduce downtime for mill maintenance, and increase mill availability and productivity.

These goals can be achieved by using our high-precision tachometer, which has a resolution of 3 mm.

**Frozen Charge Protection**

A “frozen” or “baked” charge is capable of destroying the mill body and bearings if it drops from the top of the mill after a 180° revolution. This can cause extended downtimes and considerable production losses. This specific problem of wet grinding mills was discussed between our customers and our system experts. The detailed knowledge of the technological problem together with the capabilities of the TRANSVEKTOR closed-loop control enabled Siemens to develop a Frozen Charge Protection.

In normal operation, the charge starts sliding after the mill reaches a certain angle of between 40° and 70° and the load torque decreases. This decrease in torque is monitored and used by the Frozen Charge Protection to stop the mill before a dropping frozen charge damages the mill.

**Frozen Charge Shaker™**

Stopping the mill in case of a frozen charge prevents damage to the mill, but does not completely solve the problem. After stopping the mill, the charge keeps in “frozen” condition and must be broken up with mechanical means and water. These efforts take time and cause production losses.

The SIMINE Gearless Mill Drives provides a Frozen Charge Shaker that breaks up the frozen charge and removes it from the mill body. The Frozen Charge Shaker lifts the charge to a risk-free angle, and moves the mill in a harmless range with varying speed and acceleration. The angle and movement are designed to break the frozen charge and remove it from the mill body. This feature is patented in all mining countries.
Excellence from experience  
Selected success stories with SIMINE Gearless Mill Drives

Thanks to our more than 30 years of experience in the design, planning and building of reliable Gearless Drives for mining operations, you can count on us to help you improve your position. We have installed more than 40 Gearless Drives for mills with a total of 400,000 kW of power.

We’ve also provided more than 40 solutions for optimal productivity, demonstrated by over 350 machine years of successful operation time.

The success stories presented below provide just a brief impression of our comprehensive experience.

**The first Gearless Drive for the ore industry worldwide (1979)**

| Customer: | A/S Sydvarangar, Norway |
| Plant type: | Ball mill, 21 ft |
| Our solution: | Replacement of an existing 240-t mill and a drive power of 1,100 kW |
| Technical data: | 1,000-t mill with 8,200 kW drive power |
| The result: | The new mill was positioned where the smaller mill had operated before – on the same limited floor space. Speed control was designed for 25% downward from rated speed at constant torque and 5% upward at constant power. |

**First Gearless Drive for an SAG mill worldwide (1988)**

Gearless Drive for two SAG mill copper ore grinding circuits, commissioned in 1988

| Customer: | Chuquicamata, Chile |
| Plant type: | SAG mill, 32 ft |
| Our solution: | Installation, commissioning and testing of two Gearless Drives |
| Technical data: | Two Gearless Drives rated 8,200 kW each at 10.2 rpm |
| The result: | For the first time, a cycloconverter (CCV) Drive system designed with fuseless water-cooled and short-circuit-proof thyristor equipment was used, as was a containerized electric package (E-house) instead of a standard electrical room. |

**First Gearless Drive for a 38-ft SAG mill (1997)**

Gearless Drive for SAG mill copper and gold ore grinding circuit, commissioned in 1997

| Customer: | Freeport McMoran, Indonesia |
| Plant type: | SAG mill, 38 ft |
| Our solution: | Gearless Drive, designed to transport limitations of site location |
| Technical data: | Gearless Drive with 20,400 kW for a 38-ft SAG mill |
| The result: | Siemens designed this motor according to the existing transport limitation of the road from the port to the site. The road climbs up the mountains on serpentes and through several curved tunnels. The Gearless Drive withstands the high humidity of the Indonesian rain forest. |
First Gearless Drive for a 40-ft SAG mill (1998)

Customer: Cia Minera Antamina, Peru (2011)
Plant type:
– One gearless mill drive for a 38 ft SAG mill
– One gearless mill drive for a 24 ft ball mill
Our solution: Installation, commissioning and testing of the gearless drives at an altitude of 4,300 m
Technical data: – Power: 20,142 kW for a 38 ft SAG mill
– Power: 11,190 kW for a 24 ft ball mill
Customer benefit: – Minimized downtimes
– Operational reliability
– High productivity

The result: The first Gearless Drive for a 40-ft SAG mill was installed at the Cia Minera Antamina in Peru. The drive provides a nominal power of 20,142 kW to the mill shell. The Gearless Drive of Cia Minera Antamina's 40-ft SAG mill has been running since 2011 at optimum availability to the complete satisfaction of the user.

First Gearless Drive for a 40-ft SAG mill (1998)

Customer: Cia Minera Antamina, Peru (2011)
Plant type:
– One gearless mill drive for a 38 ft SAG mill
– One gearless mill drive for a 24 ft ball mill
Our solution: Installation, commissioning and testing of the gearless drives at an altitude of 4,300 m
Technical data: – Power: 20,142 kW for a 38 ft SAG mill
– Power: 11,190 kW for a 24 ft ball mill
Customer benefit: – Minimized downtimes
– Operational reliability
– High productivity

The result: The first Gearless Drive for a 40-ft SAG mill was installed at the Cia Minera Antamina in Peru. The drive provides a nominal power of 20,142 kW to the mill shell. The Gearless Drive of Cia Minera Antamina's 40-ft SAG mill has been running since 2011 at optimum availability to the complete satisfaction of the user.

First Gearless Drive for a 40-ft SAG mill (1998)

Customer: Cia Minera Antamina, Peru (2011)
Plant type:
– One gearless mill drive for a 38 ft SAG mill
– One gearless mill drive for a 24 ft ball mill
Our solution: Installation, commissioning and testing of the gearless drives at an altitude of 4,300 m
Technical data: – Power: 20,142 kW for a 38 ft SAG mill
– Power: 11,190 kW for a 24 ft ball mill
Customer benefit: – Minimized downtimes
– Operational reliability
– High productivity

The result: The first Gearless Drive for a 40-ft SAG mill was installed at the Cia Minera Antamina in Peru. The drive provides a nominal power of 20,142 kW to the mill shell. The Gearless Drive of Cia Minera Antamina's 40-ft SAG mill has been running since 2011 at optimum availability to the complete satisfaction of the user.