

PAPER

## **BALL MILL DRIVES – PROCESS ADVANTAGES**

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## **1. ABSTRACT**

As a result of today's requirements for maximizing grinding throughput, larger ball mills with higher power demand have been developed and installed.

However, up to the present time, the minerals industry is still centered on the old ball mill drive technologies. In this paper, ABB presents the process advantages of the recent mill drive solutions, and explains the benefits this can bring to the operation. ABB mill drives capabilities and functionalities focus on process optimization, high efficiency/availability, safety, and remote diagnostics.

## **2. INTRODUCTION**

Grinding mills have been used in the minerals industry for years. Half century ago, grinding mill diameters were below 6 meters and driven by fix speed synchronous or by wound rotor induction motors with power close to 2 MW.

From there on, in order to benefit of the "economics of scale", mill sizes and power have been constantly growing.

It reached a point that the necessary torque could no longer be transmitted by one single mechanical pinion, leading to the appearance of dual pinion solutions. However, it didn't take much time to reach the dual pinion torque limits and for ABB (former BBC) to develop the Gearless solution.

The first worldwide Gearless Mill Drive (GMD) with a power of 6.5 MW was installed 1969 by BBC in a cement milling process in the cement plant Le Havre in France. In the first few years, the GMD was only used in the cement industry. Almost 15 years later, the first GMD was installed in the minerals industry. Since then, it became a proven, well established solution in the minerals segment.

Single-pinion and dual-pinion fixed-speed gear drives offer a relatively simple design. However, process flexibility and optimization can only be achieved with variable speed drives. Furthermore, mechanical problems and maintenance for gearboxes increase operating cost and reduce availability of the mills.

Improvements in power electronics technology and controls have resulted in variable frequency converters that offer high efficiency, high reliability and availability at competitive cost.

### **3. ABB VARIABLE SPEED GRINDING MILL DRIVES**

ABB ring-gear mill drive solutions offer all the advantages that come with a frequency converter using voltage source inverter technology, combined with high flexibility and additional functionality developed and customized for grinding applications. This solution is a modular concept based on ABB's drive technology and provides a common drive control platform which is used for induction and synchronous motors in single and dual pinion configurations. Therefore, these drives are ideally suited for all type of mill applications and are able to cover the power range up to the mechanical limit of the gearbox or the ring gear.

In the Gearless Mill Drive (GMD) solution, the mill becomes the rotor of a synchronous motor. The torque is transmitted through the magnetic field between stator and rotor, eliminating the gearbox, the ring-gear and the mechanical related problems faced by maintenance with ring-gear mills. The GMD is adjustable in speed, and thus can fulfill the customer requirements with respect to flexibility and adjustability of the process. Furthermore, there are no real design limits, neither in the electrical part nor in the mechanical considerations, allowing scalability of the drive nor design optimization towards specific customer requirements.

#### **3.1. SINGLE PINION VARIABLE SPEED GRINDING MILL**

The lowest electrical capital expenditure is given by ABB's high speed solution which is a combination of frequency converter and squirrel cage induction motor.

ABB's low speed solution, including a frequency converter and a brushless synchronous motor or a permanent magnet motor, eliminates the costly gearboxes of the high speed solution. Both solutions start with the motor directly coupled to the mill eliminating the need for an air-clutch required for a fixed speed solution. There is a significant reduction in mechanical parts and in maintenance, improving also the system overall efficiency.

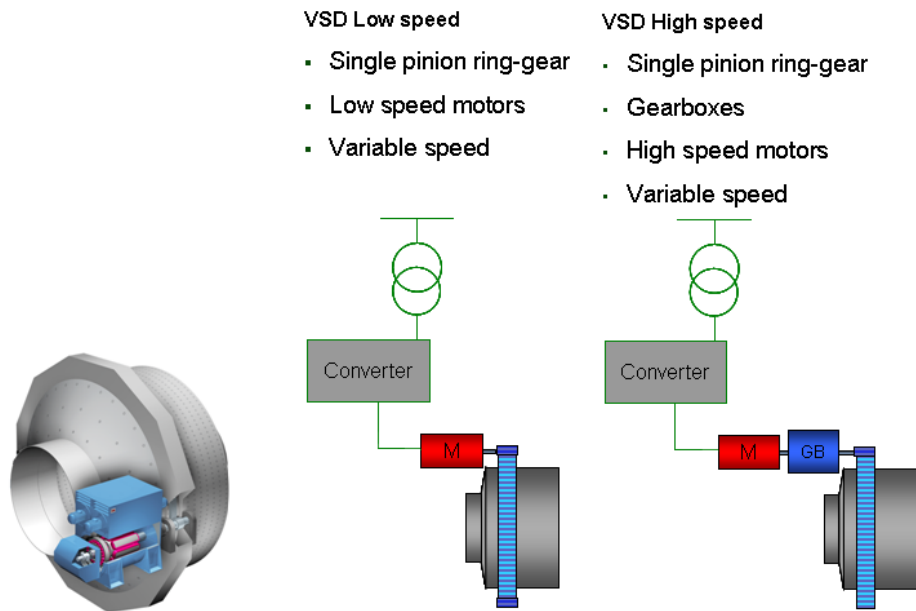


Figure 1: Single pinion mill drive

### 3.2. DUAL PINION VARIABLE SPEED GRINDING MILL

High speed and low speed options are also available for dual pinion ring-gear mills. When dual pinion mills are used, care must be taken that the load is shared equally between the two pinions. ABB's fast direct torque control (DTC) ensures an accurate and coordinated load sharing, even for synchronous motor solution. DTC is the ABB advanced motor control method for drives that allows precise control of the motor torque and speed.

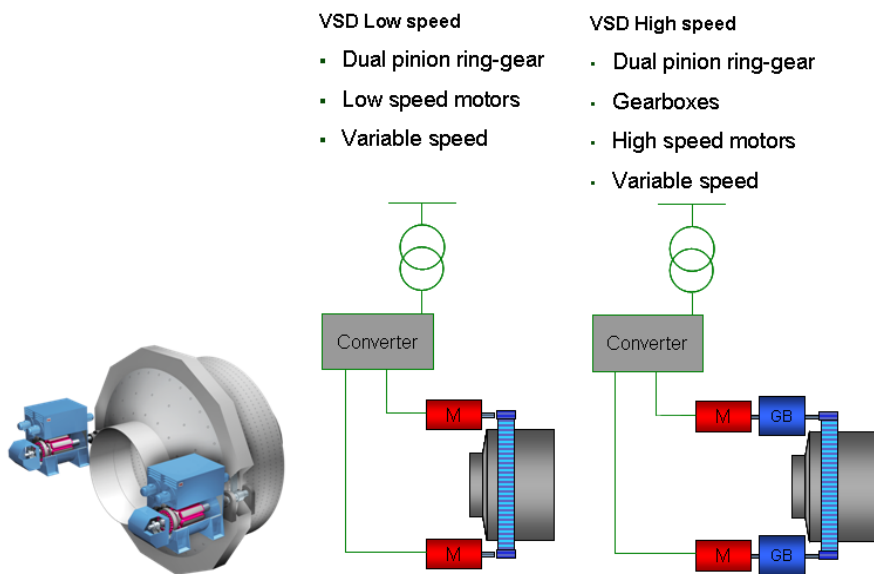


Figure 2: Dual pinion mill drive

### 3.3. GEARLESS GRINDING MILL

Gearless mill drives have the highest electrical capital expenditure; however it is compensated by the lowest mechanical investment required and by the lowest operational cost.

The gearless mill drive solution - by removing the mechanical components like ring-gear, pinion and gearbox - is able to deliver unmatched overall system efficiency and availability.

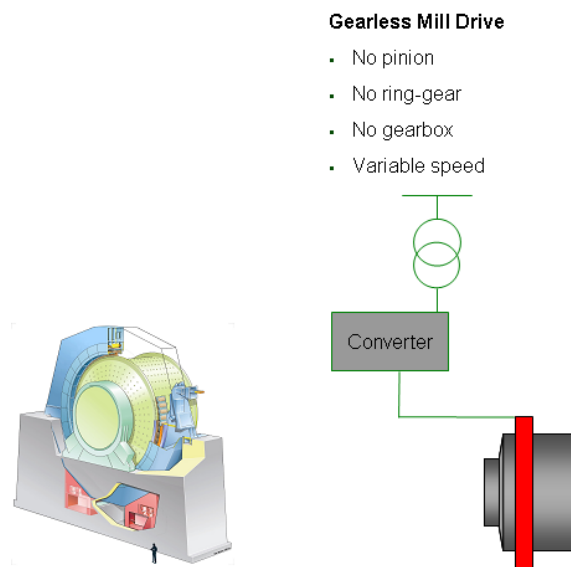


Figure 3: Gearless mill drive

### 4. FUNCTIONALITY AND PROCESS ADVANTAGES

The control of the material quality and the process optimization given by variable speed drive is an important part of the operation of the plant. This flexibility opens new dimensions for process improvements.

Within traditional fix speed process, as it is not possible to adapt the speed, the bottleneck for the whole process line is set by the limitation of one of the mills.

With variable speed process, all mills can be adjusted to its optimal performance, which leads to a debottlenecking of the line and to a higher production rate.

Please find below the ABB grinding mill variable speed drive benefits:

- **Optimization:** Speed control allows the mill to run faster or slower to find the optimal operating point, maintaining a constant output particle size despite of changing of ore grade or liner wear effect. Moreover, partial load operation at any speed is

possible. This ability means the grinding throughput can be matched to the up- and down-stream process requirements.

- **Mill Load Distribution:** The load distribution to the Ball mills is a non ideal process; it is possible to run each Ball mill with different speed according its load.
- **Liners Life-time:** Bi-directional operation, allows prolong the liners replacement. Furthermore, during commissioning and startup while running with only partial fill, the speed can be lowered. Harder liners with longer life-time can be used from the beginning, eliminating the need of softer starter-liners and the associated costs related to its replacement. The variable speed solution also avoids damage to the liners during filling, emptying and process interruptions by lowering the mill speed.
- **Expert Systems:** Expert systems, like the ABB Expert Optimizer, can take full benefit of the ball mill variable speed capability in the grinding optimization process.
- **Mill Starting Behavior:** Very smooth starting behavior with low starting currents. Low starting currents reduce network voltage dips and improve network stability.
- **Positioning:** No additional inching drive is required. The mill drive control has operating modes for creeping and accurate positioning. Creeping speed can be used for slowly rotating the mill to perform a visual inspection or grinding out the mill. Fast and automatic positioning of the mill based on angle or liner reference reduces the down time needed for changing liners.
- **Controlled Roll Back:** The drive has a “controlled roll-back” function for bringing the mill smoothly into a rest position where both speed and torque are zero. After reaching the balance the drive is switched off. Having the mill in balance load condition, allows safer and faster maintenance procedures.
- **Frozen Charge Protection:** All variable speed mill drives from ABB are equipped with frozen charge protection and frozen charge remover capability. ABB’s dedicated mill control system features critical monitoring during the starting period, protecting the mill against damage when dropping a frozen charge. As the loaded mill starts up, ABB’s control system evaluates torque build-up, ensuring that appropriate decisions are taken before a frozen charge can drop and damage the mill body or the mill bearings.
- **Mechanical Stresses:** ABB’s ring-gear mill drive solution protects the mechanics during normal operation and starting by limiting the torque. The mechanical stress on the ring-gear is reduced due to the smooth starting behavior. The precise torque control during all operating states of the mill does not generate significant torque pulsations, limiting backlash on the pinions and gearboxes.

- **Dual Pinion Load Share:** In dual-pinion configuration the torque is shared between the two motors. ABB digital drive system adjust the load every 25us, fast enough to minimize backlash, improving the mechanical availability.
- **No Clutches:** Clutches are not required with variable speed drive and allow savings in capital and operational expenditure.
- **Power Ride Through:** the ABB variable speed mill drives are able to survive network disturbances and voltage dips. When the supply voltage recovers, the drive starts back normally in speed control according to the speed set points. The surviving time depends on the energy stored in the inertia. It is a very important feature for the mining industry, since most of installations are in remote areas subjected to frequent network variations.
- **Remote Diagnostic:** ABB specialist's support, by remote access, can be provided through a secure internet connection. This allows fast access to check drive status from any global location. This supports site maintenance personnel during service and trouble-shooting and minimizes downtime and production losses.
- **Power factor:** In ring-gearred mill drives, the power factor to the network is greater than 0.95 under all conditions. If an "active front end" is included, then the drive system can operate at unity or leading power factor to the network, as required.

## 5. CONCLUSION

The functionality and the process advantages of the recent mill drive solutions have been shown. Due to the variable speed operation the grinding process can be optimized for ores with varying grinding properties. This leads to significant optimization potential for the plant design as well as for its operation. Furthermore, energy and cost savings due to optimized operation, high system efficiency, high system availability and reduced maintenance can be achieved.

## 6. REFERENCES

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