MOTION

Gearless drives for medium-power belt conveyors

ABB's new permanent magnet (PM) motors for medium-power gearless conveyor drives (GCDs) reduce production costs and increase competitiveness. A PM motor, combined with gearless technology, also fulfills eco-design requirements, saves energy, reduces failure rates and lowers maintenance overheads.

Ulf Richter
ABB Mining
Cottbus, Germany

ulf.richter@de.abb.com

Producers who handle cement, ores, rock, coal and the like are heavily dependent on high-capacity conveyor belt systems that are reliable, efficient and very robust. The hourly cost of a conveyor breakdown can be substantial, so uptime is a parameter of primary importance. ABB has long supplied conveyor systems that meet the stringent demands of producers in a wide range of industries →1.

Gearboxes

ABB classifies conveyor systems by power band →2. Low-power belts are found in almost every material-handling plant; medium-power belts are used extensively for shifting rock and coal; and high-power belts are for more dense commodities, like copper or iron ore that are transported over long distances or steep ascents.

In the high-power regime, conventional conveyor drives face challenges, mostly associated with the gearbox. Building a gearbox that can handle powers above 3.5 MW is a non-trivial task and even when built they are maintenance-intensive when in operation. Further, their lifetime is relatively short. Other challenges are posed by the vast array of drive constructions - ranging from mobile units, where motors are housed within the drive station's steel enclosure, to stationary structures where the motor is foot-mounted on concrete foundations.

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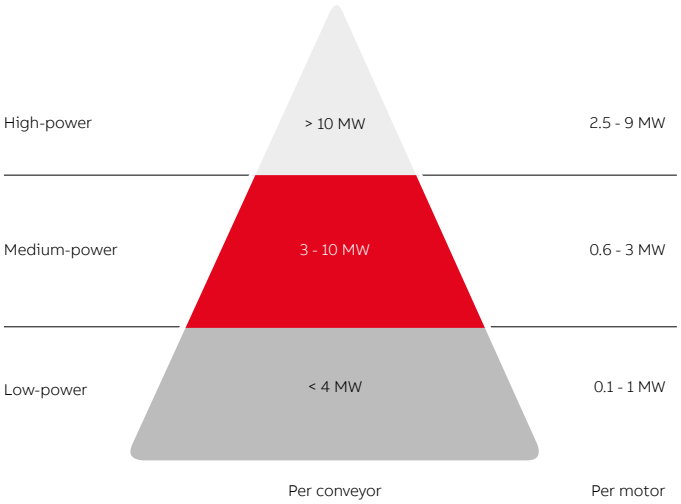
— 01 Typical conveyor drive with gearbox.

— 02 Conveyor classification according to installed power.

Such problems can be avoided by using a gearless drive. A GCD uses a large, low-speed synchronous electric motor mounted on a pulley shaft that is designed to handle the high torque produced by such motors. The motor is controlled by a variable-speed drive (VSD) to produce a shaft rotational speed of typically 50 to 70 rpm. There are usually several drive modules in a drive station and there can be multiple drive stations on the conveyor. The power of existing GCDs goes from around 2.5 to 7 MW, with a total connected power in the range of 5 to 20 MW.

A GCD is of simple construction and, because it has relatively few parts, it is long-lasting and maintenance-light.

A GCD is of simple construction and, because it has relatively few parts, it is long-lasting and maintenance-light. Indeed, drives delivered to the Prosper Haniel coal conveyor in Germany in 1985 are still running today. GCDs are also attractive from an energy-saving point of view: The gain of 2 to 3 percent they bring to the efficiency of high-power systems represents significant cumulative savings in electrical costs over the lifetime of the installation.



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However, a major disadvantage of current GCD technology is that its capital cost is high, which makes it competitive with conventional designs only in the higher power bracket and where a long operating life is foreseen. As well as cost considerations, if GCDs are to be commercially feasible in the medium-power segment, lower weight, more efficient cooling and a more compact size are required. In other words, a new approach is needed if customers with lower-power applications are to benefit from GCDs.

ABB has used its long experience to develop a series of low-voltage PM motors specifically for ABB GCDs.

New GCDs using low- or medium-voltage permanent magnet motors

Permanent magnet motors have been around for decades – in ship propulsion, pumps, fans, blowers, wind power generators, automotive, etc. Now ABB has used its long experience in this field to develop a series of low-voltage PM motors specifically for ABB GCDs.

With a power range of 1 to 3 MW, these new ABB GCDs are ideal for a large number of applications – both newbuild and retrofit – and their costs are comparable with equivalent conventional geared systems.

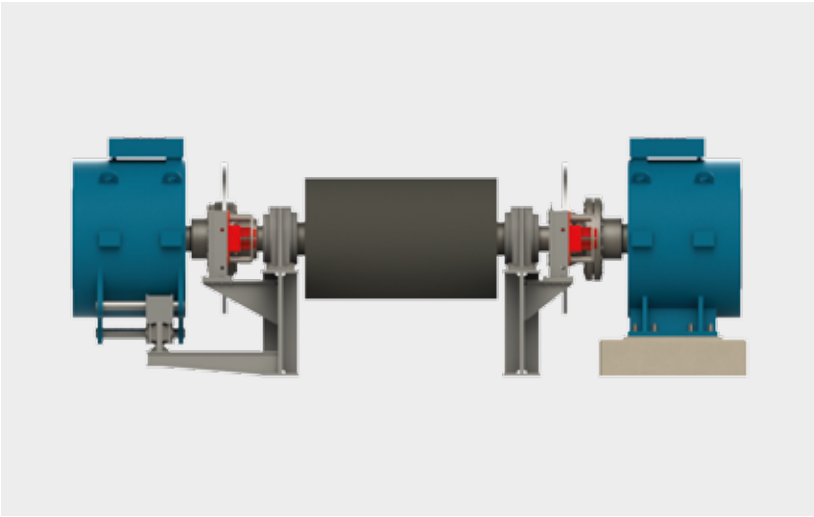
This pioneering GCD concept is lightweight, compact and can be air- or liquid-cooled →3. The motors can be foot-mounted or shaft-mounted, whereby the latter is quicker to install, easier to align and requires less concrete foundation work →4. The heavy-duty design is robust enough to deal with the shocks and vibrations associated with handling cement, rock, coal and other common mined materials. An IP66 rating means the PM GCD is completely protected from dust and water contamination. An added benefit is that the GCD has lower operational noise levels.

A PM GCD has significant operational advantages over geared equivalents:

- Fewer components, so it has a higher reliability (about 50 percent lower failure rate) and less maintenance is required
- Higher efficiency with lower energy consumption and lower noise emission
- Higher equipment utilization
- Operational cost savings (OPEX)
- Energy loss reduced by over 30 percent
- No monitoring and testing of gearboxes
- No oil (reduced fire risk)
- Extended life cycle (expected motor lifetime of 25 years is 10 years longer than with the gearbox-equipped equivalent)

	Geared with frequency converter (kW)	Gearless with frequency converter (kW)
Pump/cooler	0.6	0.6
Transformer	1.24	1.17
Frequency converter	2.44	2.31
Motor	5.88	4.9
Motor excitation	0	0
Gearbox	7	0
Total losses	**17.16**	**8.98**
Total efficiency	**89.1%**	**93.90%**

Device	Efficiency
Squirrel cage induction motor	96.00%
Gearbox	95.00%
Transformer	99.20%
Converter	98.40%
Permanent magnet motor	96.43% (can be designed for higher efficiency (~98% for PM)



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03 200 kW direct-drive PM (SyncPM) and synchronous motor comparison at 70 percent loading (140 kW).

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04 Foot-mounted (right) and shaft-mounted (left). The motor mounted to and suspended by the pulley shaft has favorable characteristics, such as quick installation or swap-out. However, the foot-mounted version is the easiest to design and dimension, especially as the motor weight has no influence on the dimensioning of the pulley shaft. The choice depends on customer preference.

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05 Cumulative cost savings of GCD versus geared drives for a cement industry conveyor system. Conveyor length: 40km; 22 drives of 1,500 kW, 136 rpm; buffer capacity of three days.

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06 The GCD package at the pilot project in the Jänschwalde mine.

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Gearless drives are especially beneficial in installations where:

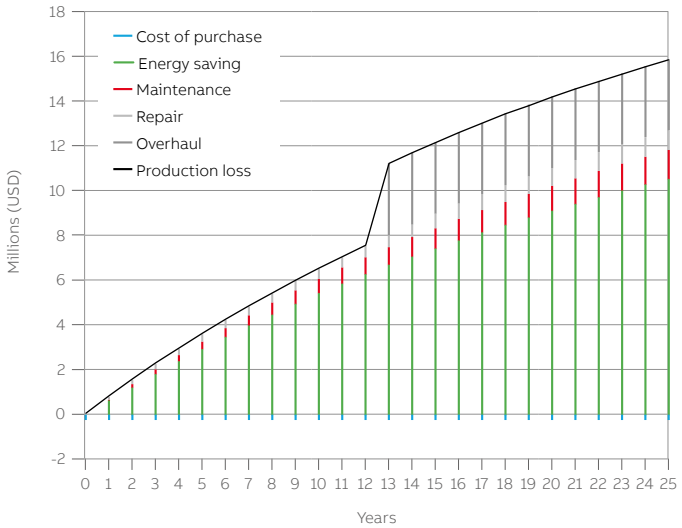
- The planned life cycle is longer than 10 years
- Gearboxes are a source of trouble
- High availability is required, or no redundant production lines exist
- Material buffers are small or non-existent
- Maintenance work is hard to perform (high altitude, high or low temperatures)
- Maintenance personnel is difficult or expensive to source
- Ambient conditions are harsh

PM GCD cost/benefit analysis - a practical example

The following example demonstrates how the new GCD can reduce operational costs for mining industry conveyor systems. It is based on the following conveyor system design:

- Conveyor line: four flights
- Drives: 12 in total
- Power: 1,000 kW
- Tonnage: 8,800 t/hr
- Energy cost: $0.10/kWh
- Gearbox efficiency: 96 percent
- Annual operation time: 6,900 hours
- Stockpile capacity: three days

The results are presented in →5. which shows the cumulative cost savings (including investment) of a conveyor system equipped with the PM GCD compared to the same system with geared drives.



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The major cost factors are energy (electricity), system maintenance, repair and loss of production. The four pillars show the saved cost for each time frame. It is obvious that savings in electricity and overhaul are most significant. After 15 years, a mine would have saved about $12 million by using the GCD.

Pilot project: retrofit of a 200 kW conveyor drive
In July 2017, after one year of planning, ABB started a pilot project with the title “gearless conveyor drive with PM motor,” with Lausitz Energie Bergbau AG (LEAG) in the Jänschwalde open-pit lignite mine close to Cottbus in Germany.

The new medium-power gearless PM drive runs in parallel to the existing geared drive on the 2.5 m wide discharge belt of a bucket chain excavator, located at the end of the discharge boom. The belt has a capacity of 15,400 tons/hour and moves sand - with inclusions of large rocks (ice-age foundlings) that give rise to mechanical shock and vibration. The ambient temperatures faced by the equipment are extreme: -25 to +40 °C.

The GCD package consists of a PM motor, frequency converter and a transformer →6-8. Both drives, geared and gearless, are connected to the same pulley shaft, which allows exact benchmarking.

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The two drives are sized according to LEAG specifications and allow 100 percent production with each drive independently. The time taken for dismantling, installing and commissioning was only two weeks.

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07 Pilot gearless drive.

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08 Before installation at the pilot site, the drive was put through its paces in the dedicated test rig at ABB.

The pilot project has established the feasibility of installing gearless conveyor drives on mobile mining machines and shows the suitability of PM torque motors to drive conveyors. The GCD so far has performed very well under the challenging conditions.

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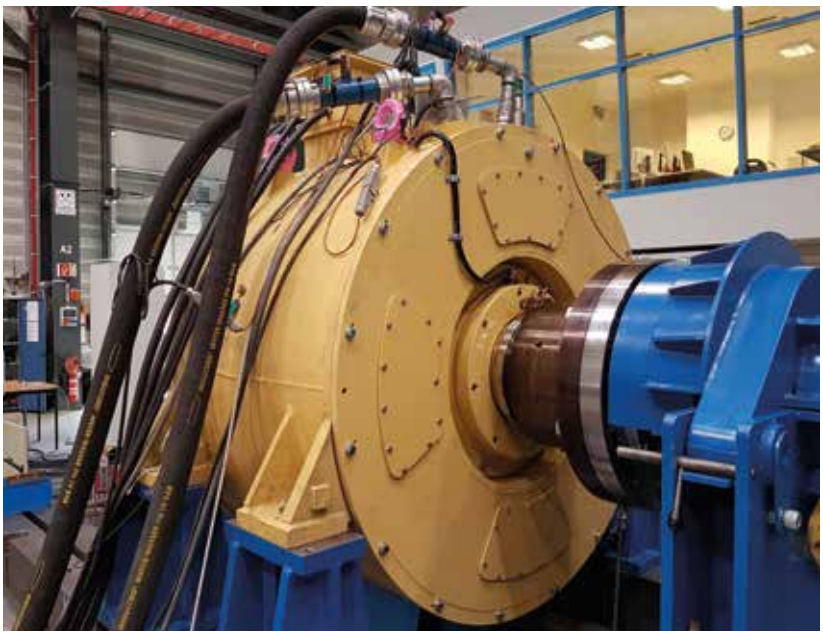
PM GCDs deliver an efficient, long-lasting and reliable solution that helps operators to increase production and annual revenue, and decrease costs.

The potential for energy savings, reduction of failure rate and maintenance, etc. have also been demonstrated. Also, the pilot project proves that it is possible to install gearless drives as an alternative to conventional geared drives and at the same time fulfill eco-design requirements according to ISO 50001 (energy efficiency) so that the environmental certifications held by mining companies is maintained.

Driving future developments

PM GCDs deliver an efficient, long-lasting and reliable solution that helps mining and other manufacturers to increase production and annual revenue, and decrease costs. PM GCDs drastically reduce the effort for maintenance, repair and asset management. While the upfront investment is typically higher when compared to a conventional drive (for a 1.5 MW GCD, the investment for the electric drive is about 10 to 20 percent higher; the combined cost of mechanical and electrical equipment will be around 5 percent higher), the savings in maintenance, energy cost and downtime lead quickly to a return on investment of typically less than one year. When analyzing the total cost model for a GCD acquisition, it should be borne in mind that the conveyor system usually occupies a critical path in the mining or production facility - should the conveyor malfunction, the work rates of excavators, crushers and other processing equipment will be adversely affected too.

The introduction of a GCD for medium-power conveyor drives based on a PM synchronous motor offers exciting possibilities for cement and mining applications. This new concept allows implementation of a gearless motor into an existing or new medium-power conveyor – an exercise that has been practically difficult and commercially infeasible using conventional gearless motors up to this point. ●



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