

WHEN LESS IS **MORE**

URS MAIER, ABB TECHNOLOGY CENTRE FOR MATERIAL HANDLING AND GRINDING, SWITZERLAND, EXPLAINS THE COST AND OPERATIONAL BENEFITS OF USING GEARLESS CONVEYOR DRIVES FOR THE NEW GENERATION OF LONGER AND HIGHER CAPACITY OVERLAND CONVEYORS.

The coal mining industry is increasingly turning to overland conveyors as the preferred method of transporting its product from the mine to the processing plant or coal terminal. A combination of various factors drives the demand for longer conveyor systems and greater conveying capacity. Among them are lower ore grades, longer transportation distances, higher throughput, as well as the fact that overland conveyors are an environmentally friendly and cost-effective way to transport coal. As a result, coal

mining companies are switching to longer and higher capacity conveyor systems when possible.

But how can mining companies be certain that longer, higher capacity and technically more demanding conveyor systems will operate with maximum availability and reliability and with the lowest possible operating costs?

Although there are several different electrical and mechanical technologies for operating overland conveyor systems, there is widespread acceptance today that electrical

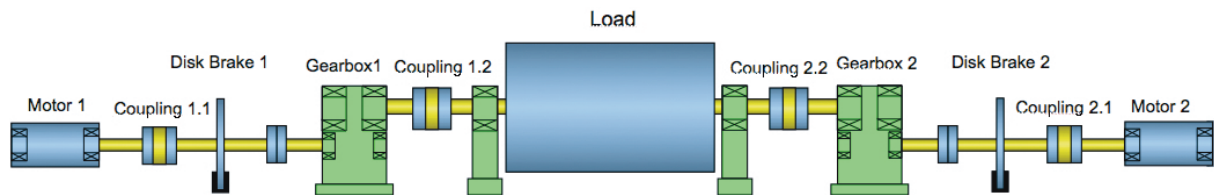


Figure 1: Geared high-speed twin drive with SCIM (e.g., 2 x 3 MW).
Wear parts: >22.
MTBF: 3 – 4 years.

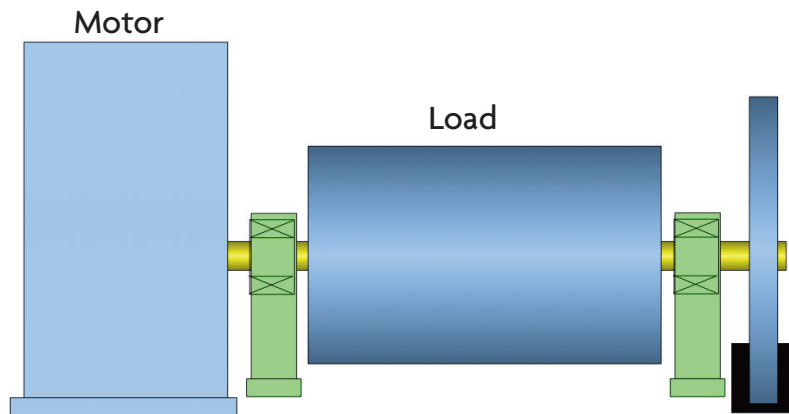


Figure 2: Gearless low-speed single drive with synchronous motor (e.g. 1 x 6 MW).
Wear parts: 2.
MTBF: >30 years.

drive systems are the most efficient and cost-effective on the market. As a generalisation this is true, but not all electrical drive system technologies offer the same benefits. The traditional conveyor electrical drive system consists of an electrical motor with a gear reducer and coupling in a single or multiple drive configuration, often without soft-starting capability. There are several disadvantages when starting and operating belt conveyors with these devices, including:

- High tension peaks in the belt during start-up.
- High starting currents in the network.
- Higher system and load sharing losses.

These disadvantages result in increased maintenance costs and higher production losses. But by far the biggest disadvantage of these traditional systems is the gear reducer. Why is this?

To begin with, the power rating of the angular gear reducer is limited to just 3.2 MW, or 500 kNm. Secondly,

gear reducers are maintenance intensive and consist of many parts: sealings, filters, sensors, oil pumps, re-cooling units, etc. Not surprisingly, the mean time between failures (MTBF) for a gear reducer system is usually 3 – 4 years. On top of that, there are the bearings. Although they have an operating life of 8 – 10 years, replacing them requires a major system overhaul. Thirdly, the operating life of the gear reducer is comparatively short. Whereas a conveyor system is designed to last 20 – 25 years, gear reducers last only half that time – about 10 years on average.

Geared vs. gearless

Comparing a conventional gear-based electrical drive system with a gearless drive system, the differences are immediately apparent (Figures 1 and 2). To achieve a power rating of 6 MW, a conventional geared solution requires up to four high-speed drive systems, each comprising a squirrel cage induction motor, disc brake, couplings, and gear reducer equipped with numerous parts, such as motor and gear bearings, seals, tooth wheels

and oil lubrication with a re-cooling unit. The number of wear parts is accordingly high (more than 22) and the MTBF is correspondingly low (only 3 – 4 years).

A gearless electrical drive system, on the other hand, is simple and long-lasting. The same power rating of 6 MW can be achieved with just one drive system, comprising a single 6 MW synchronous motor. The number of main wear parts is no more than two, resulting in an MTBF of up to 30 years, which comfortably exceeds the expected operating life of the overland conveyor system. There is also a considerable reduction in the drive system's footprint and the amount of instrumentation required.

The elimination of numerous mechanical and electrical components increases the reliability and efficiency of the overall conveyor system by several percentage points. It also substantially lowers the maintenance requirements of the gearless drive system compared with a conventional drive system, for which gear reducer maintenance alone can amount to up to 5% of the mechanical maintenance budget. Lubrication and gear reducer cooling systems, together with their maintenance, are not required with gearless drives.

System reliability and cost savings can be further improved by using a bearingless motor in the gearless drive system. A low-speed 6 MW gearless and bearingless motor can reduce CAPEX and OPEX by as much as 7% over a 20 year period compared to a high-speed geared twin-drive system. Although a bearingless motor is virtually maintenance-free, the main savings come from the significantly lower production losses that are achieved because of the reliability and availability of the drive system.

Gearless drive systems: the main components

The benefits of gearless conveyor drives derive from the four main hardware and software components that comprise the system: low-speed synchronous motors, frequency converters with voltage source inverters (VSIs), converter transformer and advanced conveyor control software.

Low-speed synchronous motors

A single 6 MW synchronous motor has sufficient torque (>2300 kNm) to attain the maximum possible torque that can be transferred between one pulley and one conveyor belt. The fact that only one motor is required (compared to the

two motors of a geared system) halves the electrical and mechanical equipment required to power and operate the drive system (transformer, frequency converter, motor, foundations, driven shaft ends, etc.). This not only reduces maintenance and the risk of failure, it also frees up space and improves access by making it possible to install the disc brake on the opposite side of the pulley to the motor (Figure 3). The interface between the motor and the pulley shaft is located outside the motor, which enables the pulley to be quickly and easily disconnected from the motor in case of wear or a fault.

In terms of efficiency, there is a significant difference between the efficiency curve of a gearless motor and

those of a squirrel cage motor and wound rotor induction motor (Figure 4). Quite simply, the higher the power rating of a synchronous motor, the higher the efficiency (the difference is significant). Even at part load (down to about 45% of maximum load), the efficiency curve of a synchronous motor continues to increase, whereas that of a squirrel cage motor drops markedly at 60% of maximum load.

Frequency converters for gearless conveyors

There are several possible drive solutions for gearless synchronous motors, all of which are based on single or multidrive configurations using cycloconverters or VSIs. Cycloconverters use old technology and have a poor power factor. They pollute the network with high harmonics and interharmonics that stress other equipment in the plant.

On the other hand, network-friendly VSIs in single or multidrive configurations are more suitable for gearless conveyor systems. VSI drives operate the motors smoothly and accurately during start-up and at the required low frequency of 5 – 8 Hz. And they have the added advantage of providing a high power factor within the entire speed and load range.

Single drives are used if there is only one motor to be operated at the head or tail end of the conveyor belt. They are available for 1 to 4 quadrant operation with diode or active-front-end low-harmonic supply sections. Multidrives are highly modular solutions. The same supply sections as for single drives are also available to feed the common DC bus. Redundant systems might have two parallel supply sections. Depending on the conveyor configuration, several inverter sections can be connected to the common DC bus to control individual motors. If there are conveyors in series, the motors at the head end of one conveyor and the tail end of the next conveyor can be connected to the same multidrive.

Advanced conveyor control software

Variable-speed gearless drive systems are the muscles that drive the conveyor belts in the most efficient and reliable way

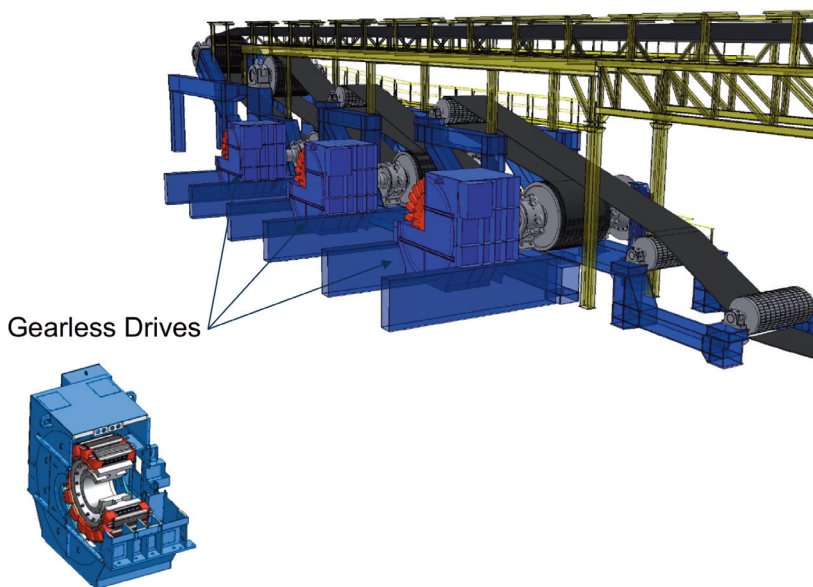


Figure 3: General arrangement of the main drive station for a Takraf conveyor system with ABB gearless drives on one side and disc brakes on the other side of the pulley.

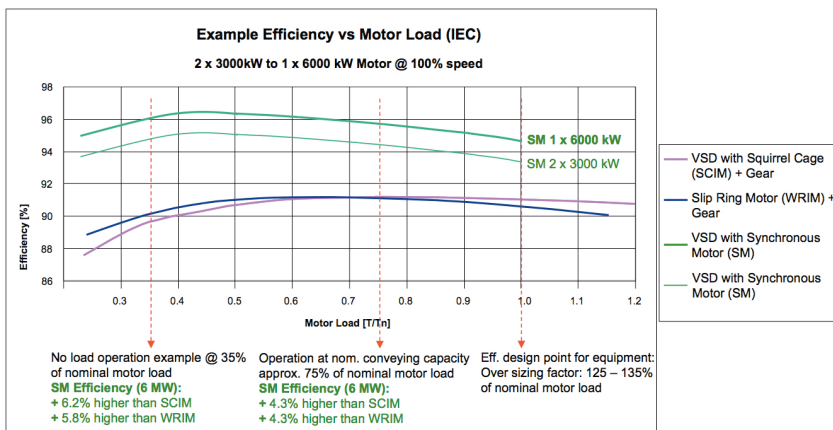


Figure 4: Example of efficiency curves at different loads for geared SCIM, WRIM and gearless SM.

possible. Muscle, however, is not enough: the conveyor system requires a brain as well.

ABB's Mining Conveyor Control Program (MCCP) is the brain for load-sharing drives in conveyor applications. It provides all the essential functions and manages the critical and high-speed communication requirements for multi-motor conveyors. MCCP is a software package that is loaded into the control board of the variable-speed drives (geared or gearless). The software is specifically configured for conveyor applications. Vital functions, such as conveyor start/stop control, acceleration and deceleration profiles, mechanical brake control, alarm processing, over and under speed limits and torque limits, are all set by parameters in the MCCP.

The conveyor master control sends torque reference signals to all follower drives. Each of the followers transmits data back to the master, which uses the

data as input information for the speed regulator and load sharing control loop. The communication cycle time is less than 5 milliseconds, which allows the system to act and react efficiently during the conveying process.

The benefits of MCCP include the following:

- It requires little supervisory controller capacity.
- It is compatible with all types of control system.
- It reduces the need for engineering.
- It is suitable for single or multi-motor control.
- It provides motion monitoring and protection.
- Its drives start-up and commissioning tool makes motion tuning quick and easy to implement.

MCCP has the further advantage of incorporating a conveyor simulation

model that simulates real life situations, identifies control schemes and determines basic controller settings before the software is installed and running onsite. This delivers flexibility and reduces the risk of unexpected disturbances during commissioning of the drive system. Conveyor simulation is performed by ABB during project engineering, thereby reducing the need for onsite engineering.

Conclusion: the benefits of going gearless

The benefits of a gearless conveyor drive system with low-speed synchronous motor include:

- Compact footprint and simple design.
- Higher efficiency than with an induction motor (no slip losses).
- No gear reducer losses.
- Significantly fewer components.
- Drive train free of oscillation.
- Virtually maintenance free.
- No cooling, monitoring and supervision of the gear reducer and oil coolers/heaters.
- No backlash during oscillations and at load reversals.
- Faster installation and commissioning.
- Higher system reliability and availability.
- Proven advanced conveyor control and simulation.
- Significantly lower production losses thanks to the exceptional reliability and availability.

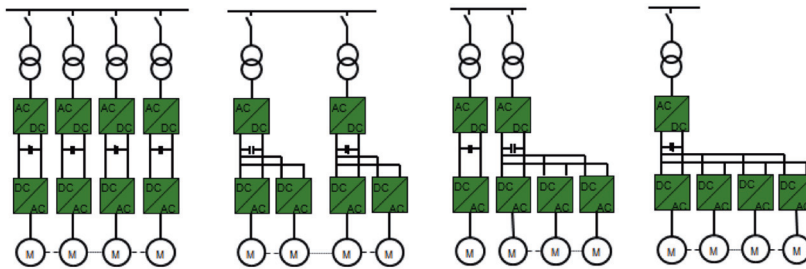


Figure 5: Modular drive system solutions. From left to right: 4 single drives; 2 multidrives, each with 2 inverters; 1 single drive and 1 multidrive with 3 inverters; and 1 multidrive with 4 inverters.

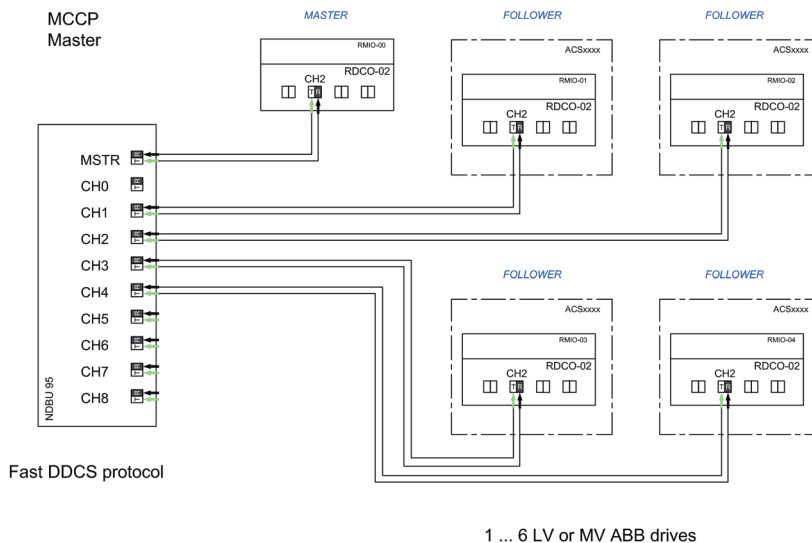


Figure 6: MCCP conveyor controller with 4 drive followers.

ABB has already delivered over 100 mine hoist drive systems – an application that uses the same technology as gearless conveyor drives, but in more demanding conditions. The number of start and stop cycles is significantly higher, for example, and the application is characterised by frequent changes between motor and regenerative operation. The company has already been awarded orders for gearless conveyor drives and is in advanced discussions with other customers in various parts of the world. Now the industry is waking up to the benefits of using gearless drive technology in conveyor applications too. ¹⁷