Conveying progress

ABB delivers reliable and almost maintenance-free gearless conveyor drives for high-power and high-torque applications

MARCELO PERRUCCI – With mining activities advancing into ever-remoter regions in which infrastructure is sparser, processing plants are often located further from the mine. Ore must be transported over longer distances (and sometimes underground) raising fresh challenges for conveyors. Conveyors may have to cover distances in the tens of kilometers and ascend steep gradients. At the same time, higher transport capacity is being required. To increase overall reliability, mining companies also want fewer transfer stations between conveyors, wherever possible. These requirements translate into wider and longer belts and thus higher torques being transmitted to the pulley shafts. Conventional solutions are limited by the power and torque restriction imposed by the gearbox. Partnering with the market-leading OEM, TAKRAF GmbH, ABB introduced conveyor systems meeting these increased demands while at the same time delivering radically higher reliability. Such an installation is being delivered to the mining company Codelco for the project El Teniente in Chile.

ABB and TAKRAF GmbH set about developing a low-speed drive technology addressing the main issues facing gear reducers.

Conventional conveyor transmissions face several limitations. First, the feasibility of a gear reducer with a power rating above 3.5 MW is very limited. Second, at high powers gear reducers are maintenance-intensive. The bearings of the gear reducer, together with the lubrication pump of the sealing, oil re-cooling devices, etc., can have an MTBF[1] of as little as three or four years. Changing bearings is linked to a major overhaul (failures on input bearings are most common).

Third, the operating life of the gear reducer is comparatively short (about 10 years on average). For example, a mine operation that is expected to last 20 years will require that the gearboxes be exchanged at least once during the life of the plant.

Studying the drive train of a 6 MW conveyor belt with the conventional solution reveals a count of more than 22 parts liable to wear and tear ➔ 1.

To achieve a power rating of 6 MW, the conventional geared solution requires two drive systems, each comprising a squirrel cage induction motor, a disc brake, couplings, and a gear reducer equipped with numerous parts such as motor and gear bearings, seals, tooth wheels and an oil lubrication with re-cooling unit.

Recognizing the need for a more efficient and reliable solution, ABB signed a worldwide agreement with market-leading OEM, TAKRAF GmbH, in 2011. The partners set about developing a low-speed drive technology addressing the main issues related to gear reducers.

Go gearless!

The solution developed eliminates maintenance-intensive gearboxes and creates a gearless conveyor drive (GCD) for high-power applications. It uses a synchronous motor attached to an adapted pulley shaft specifically designed to support the high forces produced by the electrical machine.

The synchronous motors run at very low speed and are driven by a frequency converter modulating the frequency and amplitude of the sine wave for full control of the application. This approach features all advantages inherent to such a

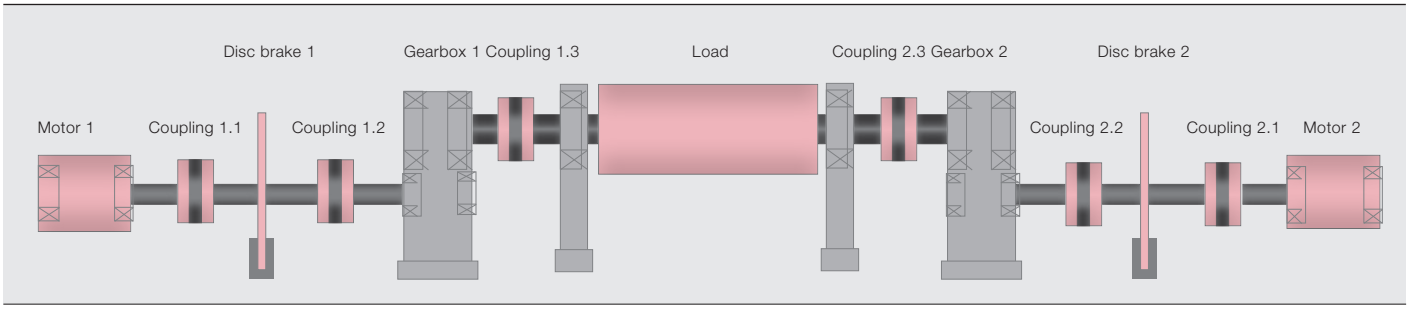
Footnote

1 MTBF: mean time between failures

Title picture

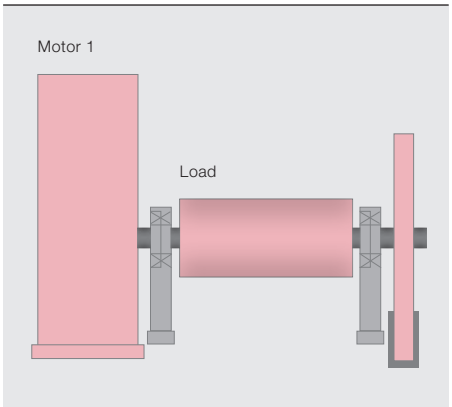
Ores are being transported over longer and longer distances, raising fresh challenges for conveyors. This picture was taken at the El Abra copper mine in Chile.

1 Geared drive with induction motors and gear reducers (eg, 2 × 3 MW)



Wear and tear (parts): > 22; MTBF: 3 – 4 years

2 Gearless single drive with synchronous motor (eg, 1 × 6 MW)



Main wear and tear (parts): 2
Motor MTBF: > 30 years

converter, including smooth control, controlled starting torque at very low frequencies, high power factor (which can be also be controlled to be 1, leading or lagging), and variable-speed control.

The frequency converters used in the GCD can be single drives, if only one motor is to be operated, or multidrive, where several inverter sections can be connected to the common DC bus with motors controlled individually. The latter approach can reduce cabling and installation costs as well as eliminate items such as individual transformers and circuit breakers. The converters can also operate in regenerative mode for downhill conveyors.

In contrast to the conventional solution, the drive train of the GCD system is simple and impressively long-lasting. The 6 MW power rating mentioned in the example above can be achieved with just one drive system, comprising a single 6 MW synchronous motor. The count of parts exposed to high levels of wear and tear is no more than two, with an MTBF of up to 30 years.

The configuration of the GCD solution ➔ 2 clearly contrasts that of the conventional solution ➔ 1.

> The entire drive train is dimensioned to withstand the bending forces on the shaft, even during abnormal operating conditions such as earthquakes or short circuits.

Bearing or bearingless?

ABB and TAKRAF jointly developed a concept that can eliminate bearings on the motor side, dramatically increasing the availability of the system compared with the conventional geared solution, reducing acquisition and operating costs.

The entire drive train is dimensioned to withstand the bending forces on the shaft, even during abnormal operating conditions such as earthquakes or short circuits. This solution has a number of advantages for customers, such as the reduction of weight and length of the entire drive train, reduction of spare parts and ease of maintenance.

On the other hand, the equivalent installation with bearings also brings great flexibility for customers who have limitations in the installation, eg, when the conveyor's drive pulley is suspended several meters above the ground and concrete bases become unfeasible. Bearings are used as a good support to ensure a frictionless rotation of the conveyor pulley shaft, and can also help make the drive train more stable, reducing the requirement for reinforced foundations. ABB and TAKRAF are thus offering both solutions. The optimal choice depends on the particular customer and project ➔ 3.

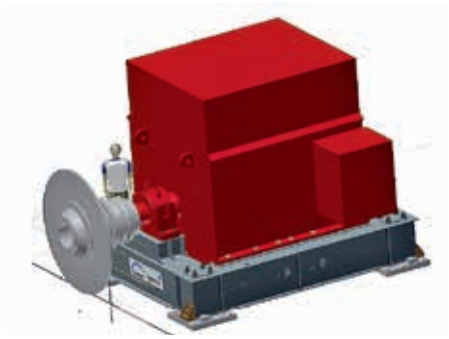
Teniente project

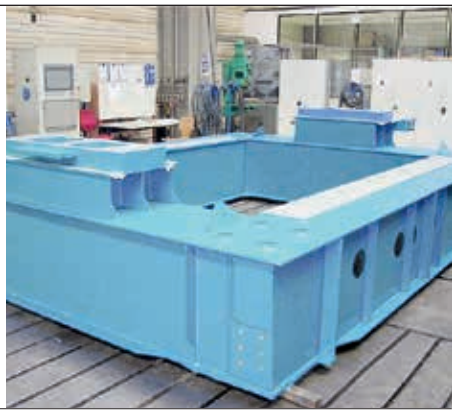
ABB has won an order to provide electrical equipment, including its new GCD, for Codelco's largest operation in Chile. The contract was awarded by Tenova

3 Comparison of bearing and bearingless solutions

Parameter	Solution with bearings	Solution without bearings
MTBF	Limited lifetime of bearings	Higher
Reliability	Reduced due to bearings and couplings	Higher
Requires additional supervision	Yes (for the bearings and coupling)	Yes (for air gap)
Lubrication system for bearings	Yes	No
Weight for transportation	45 t (higher and lower payloads exist)	30 t (higher and lower exist)
Crane capacity	Higher (only 1 piece)	Lower (can be divided in rotor and stator)
Coupling	Yes (Flexible)	No
Additional spare parts	Yes (bearings, coupling)	No
Drive train	Longer	Shorter
Capex and opex costs	Higher	Lower
ABB/TAKRAF solution available	Yes	Yes

4 Motor base frame made by TAKRAF





The electrification of the new gearless overland conveyor is part of an overall $ 550 million expansion at the El Teniente mine.

TAKRAF from Leipzig, Germany (as the main contracting party for the conveyor system) in December 2012.

The electrification of the new gearless overland conveyor is part of an overall $550 million expansion at the El Teniente mine, located approximately 70 km south-east of Santiago de Chile.

Project scope

The total scope of the El Teniente project is not limited to the GCD's drive train. ABB was able to contract the full scope of electrical equipment beginning at the end terminals of the feeding medium-voltage trail cable down to the motor shaft including all main and auxiliary power distribution equipment, sensors, customized E-houses, field instrumentation, cooling equipment as well as the control and automation system.

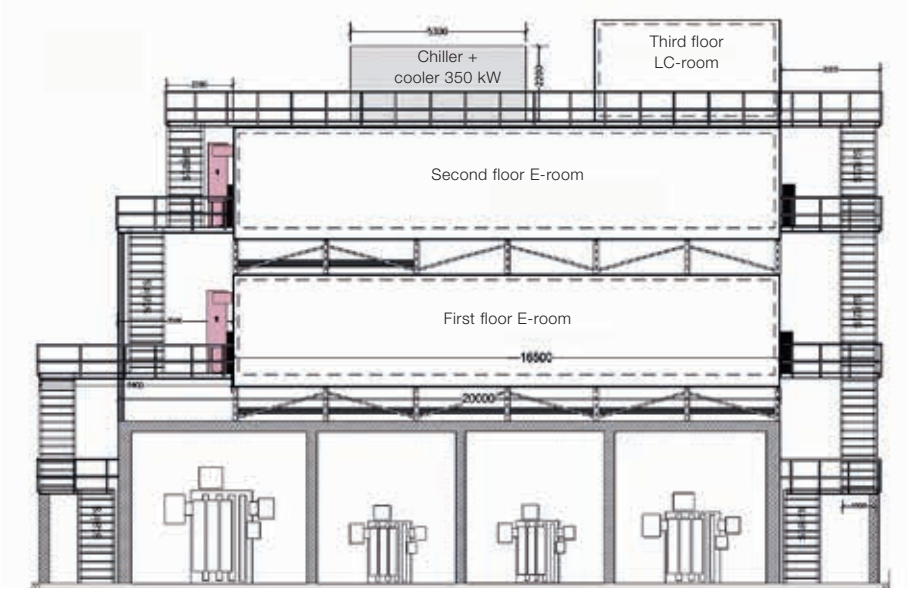
Main motors

In total 12 motors of 2.5 MW, 56 rpm are to be supplied. Low-speed synchronous motors, as typically used in gearless mine hoists, serve as a basis for the motor concept. In addition, the motor had to be adapted for the conveyor application. For example, a means of easily realigning the motor after aligning the conveyor's drive pulley was needed. For this purpose, the motor is mounted on a special base frame constructed by TAKRAF → 4. The creation of this frame required a close collaboration between TAKRAF and ABB.

E-houses

The four E-houses are fully sealed and seismically proofed containers. Each E-house contains gas-insulated medium-voltage switchgear (SX2) with two incoming feeders. Furthermore the containers house motor controllers, low-

5 Space restrictions required the E-houses for CV-01 to be positioned above the transformers.



voltage switchgear (from ABB), UPS[2] with batteries as well as air conditioning, PLCs[3], communication panels, fire detectors and extinguishers. In addition space is reserved for the customer's own interfacing cabinets.

The containers are specifically designed for the demanding site conditions such as limited space and accessibility on rock ledges; heavy snow loads; and seismic requirements. The conveyor CV-01, for example, is designed as a three-story construction resting on top of the transformer boxes ➔ 5. Other E-houses have to be split in up to six sections for transportation.

Control equipment

Each E-house is equipped with redundant ABB PLC AC800M PM864 controllers. The controllers serve as the processing units for the main drives of the belt conveyor, auxiliary drives and field devices.

Communication is based on the redundant Ethernet MMS, redundant Ethernet Modbus TCP and redundant PROFIBUS DP fieldbus network to link, for example, to:

- S800 remote I/Os
- Dupline channel generators
- Belt monitoring devices
- CCM smart starter and VFDs (variable-frequency drives)
- Cooling unit for VFDs and motors ➔ 6
- Belt scales

The 6 MW power rating can be achieved with just one drive system.

- SOBO brake controllers
- Pt100 modules for temperature monitoring
- Counter modules for speed and slip monitoring (driven pulleys and non-driven pulleys)

Software

The controller applications are structured in a standardized and easy-to-read way according to ABB standards. The application is based on ABB's System 800xA Minerals Library. A set of purpose-built ABB software modules were developed to support the conveyor application.

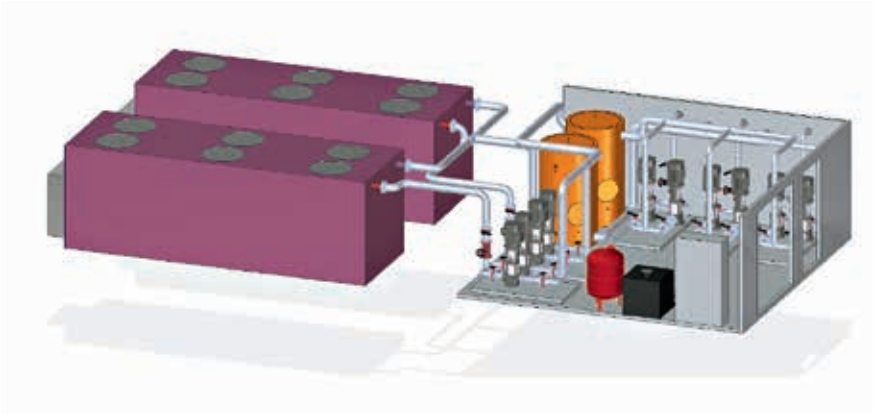
Central control station

Operators will obtain all necessary process information through five operator workplaces in the form of graphical

Footnotes

2 UPS: uninterruptible power supply
3 PLC: programmable logic controller

6 Cooling circuit for drives



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screens, alarm and event lists, and trending displays to monitor and control the equipment. Operators can control and monitor the process but cannot change parameters or configuration settings.

Main drives control

ABB VFDs are integrated with a high-speed drive bus interface (DDCS) for controlling the main drives control and with PROFIBUS DP to read diagnostic information.

ABB's Mining Conveyor Control Program (MCCP) provides the main control for the conveyor. The sophisticated control loop is superior to traditional control methods (such as basic master-follower) in control accuracy and flexibility. Special attention is given to the starting of the shared load and to shared operation between the motors in order to mitigate high torque peaks and longitudinal oscillation in the belt.

MCCP ensures that all connected frequency converters apply the same torque to the conveyor, whereas defined load sharing between different pulleys can be adjusted. In addition all necessary limitations, supervision and protection functions are included in MCCP.

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