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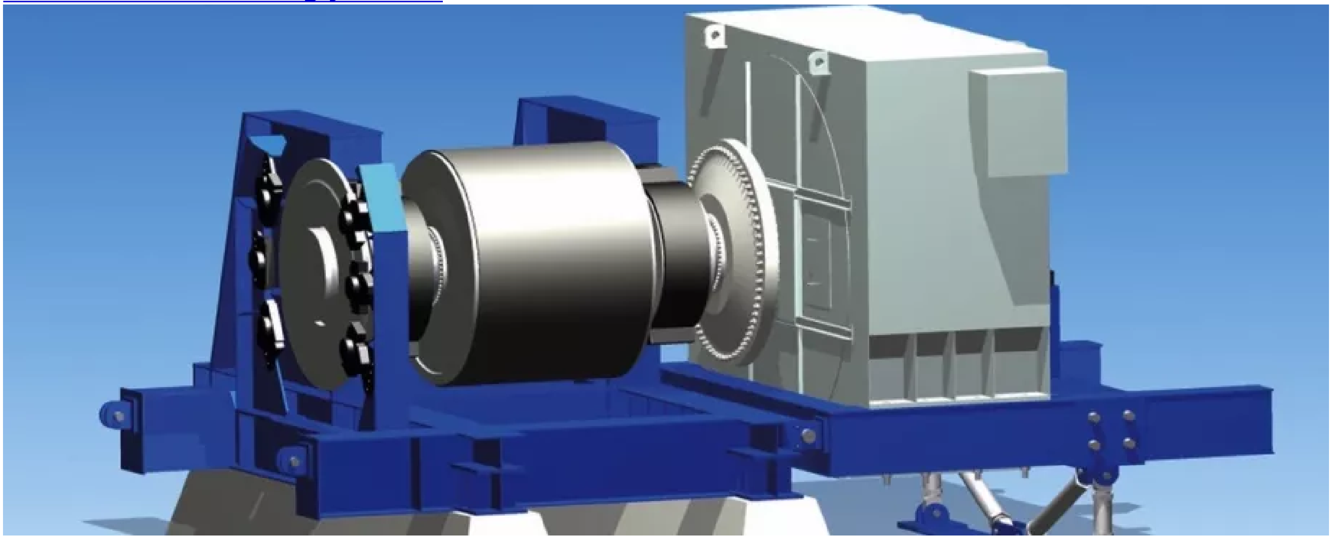

Product News

Gearless Belt Conveyor Drives – New Technology for high Capacity Systems

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Leipzig, Germany –

Belt conveyors in hard rock mining further the development of belt conveyor components on the high end of their performance spectrum. New, superior requirements regarding conveyor geometries and the range of mass flows demand to think about alternative drive concepts.

When it comes to drive sizes exceeding 3500 kW per individual drive, there are no conventional drives with electric motors and helical bevel gears. Gearless drives, like those implemented for mine hoists in underground mining operations, allow the use of larger drive units and are increasingly being utilized to drive belt conveyors.

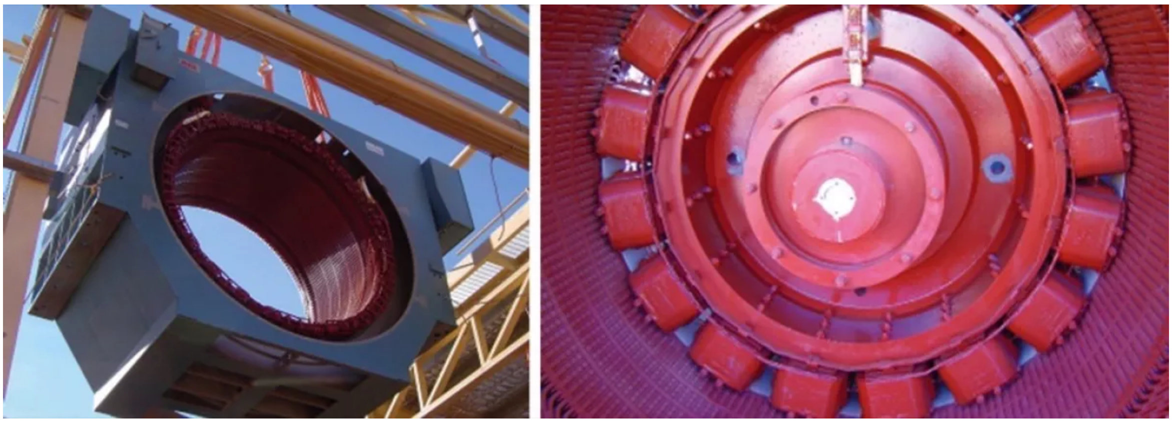

Fig. 1: Stator (left) and rotor (right) of a synchronous motor without gear during installation.(Picture: © ABB)

Introduction

Individual belt conveyors in hard rock mining operations all over the world nowadays extend over distances of more than 16 km and overcome height differences of up to 500 m, while normally achieving outputs of approx. 12000 t/hr. Such belt conveyors have had a significant impact on the development of individual components. Conveyor belts with strength of up to 7800 N/mm are actually in use today. In South American copper mines such belts are driven by electromechanical drives, consisting of electrical motors (wound rotor or squirrel cage motor) and helical bevel gears with a capacity of up to 3150 kW each. The performance requirements of belt conveyors are redefined by lower ore contents and deeper deposits. Nowadays conveyors are routed through tunnel systems such that the maximum length available is required in order to reduce the number of underground transfer stations. This places higher demands on the quality and strength of the conveyor belts. Today, the St 10.000 with strength of 10000 N per Millimeter of belt width is available. An alternative for continuously improving belt quality with ever-increasing drives located at both ends of the conveyor is to optimize the application of drive forces on the belt. Possible alternatives include:

- Belt on belt drives (TT-drives)
- Intermediate drives in the top strand and/or bottom strand
- Motorized carrying rollers [1]

Unfortunately it is not always possible to implement such advanced drive concepts. For driven carrying rollers, for example, there is still no cost-effective and reliable solution. That’s why the current development projects focus on adapting conveyors with the traditional head and/or tail pulley drive systems to new challenges and demands. Takraf is currently (article published in 2014, Ed.) involved in studies that focus on a belt conveyor system that utilizes St 10000 belts. The limits of conventional drives with helical bevel gears are exceeded with the required drive capacity of 21000 kW per individual conveyor. Low-speed synchronous motors, like those frequently implemented as drive solution for mine hoists in underground mines, permit larger drive capacities. As part of the above-mentioned study, a conveyor is equipped with three gearless drives of 7000 kW each.

Gearless Drives – Maintenance and Efficiency

The advantages of gearless drives compared to electromechanical drives cannot be reduced to the possibility of installing larger drive units alone. The curve of the motor's efficiency in relation to the motor's torque shows over the entire spectrum values that are higher than the characteristics of traditional conveyor drives with asynchronous wound rotor or squirrel cage motors completed with gears (Fig. 2).

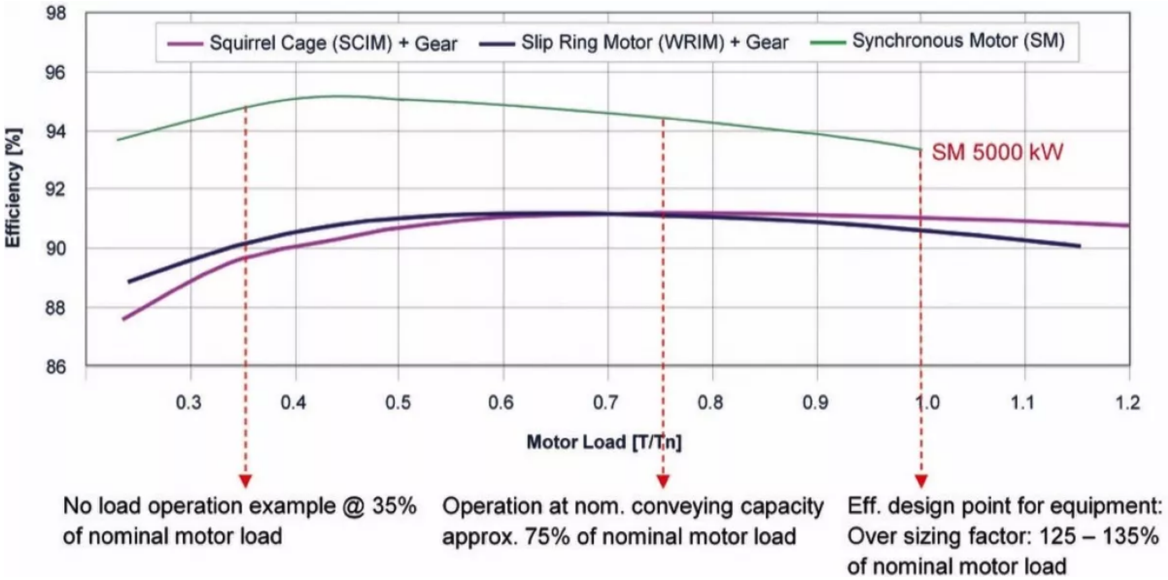

Fig. 2: Comparison of motor concepts: efficiency vs. motor load for a single 5000 kW synchronous motor vs. 2 x 2500 kW asychronous motors with gears. (Picture: © ABB)

Furthermore, belt conveyors do not always work at full load over the entire period of operation. Partial load conditions and even (short-term) idle periods are all part of a belt conveyor's operating regime. In contrast to asynchronous motors, the efficiency of synchronous motors increases in the range of partial load (Fig. 2). The higher efficiency of synchronous motors in general and especially in the partial load range and the fact that mechanical loads are eliminated during transfer of torque lead to lower operating costs for the conveyor. The maintenance of the gear unit including oil change intervals can be omitted just like the maintenance of the high-speed coupling. This is of particular interest wherever maintenance processes involve considerable effort. Prime examples of this would be operating conveyors in Canada at ambient temperatures of -45°C or conveyor systems set up at an altitude of 4500 m and more above sea level, such as in Chile.

Structure of Gearless Conveyor Drives

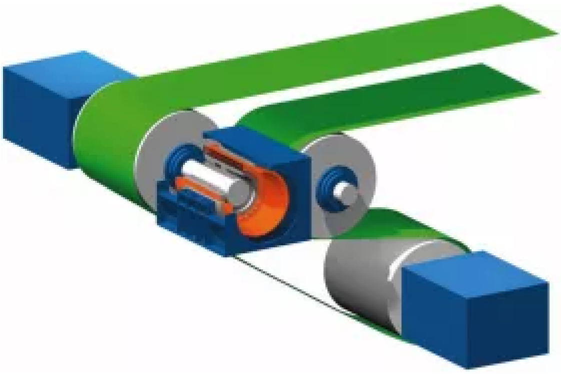

Fig. 3: Basic structure of the drive system. (Picture: © ABB)

A synchronous motor consists of a rotor that is connected with the drive pulley shaft and a stator that rests on a foundation or a corresponding steel structure (Fig. 3).

Compared to conventional belt conveyor drives, the drive unit with gear box and asynchronous motor is replaced with a synchronous motor. The following conditions must be taken into consideration if gearless drive systems are used:

- Deflection of the drive pulley shaft at the shaft end due to varying belt tensions at the different load and operating conditions.
- Possible settling of the stator foundations or deformation of the steel structure used to support the stator.
- Possibility for readjusting the entire drive in case of belt misalignment during commissioning.

A prerequisite is the need to comply with the permissible deviations in the motor’s air gap. Since the design of the motor, motor mount, drive pulley and the associated steel structure are closely tied together, Takraf entered into a cooperation agreement with ABB. This agreement allows to select a joint motor concept already during component planning, considering client specifications as well as site conditions. The following systems are worth considering as a motor concept:

- Bearingless motor: The rotor is directly connected to the drive pulley shaft (by means of a flange connection), whereas the stator of the drive motor is supported separately.
- Motor plus separate bearing: The rotor has two bearings. The stator is secured to the foundation or steel structure.A flexible coupling facilitates the transfer of torque between rotor and drive pulley.
- Diaphragm coupling: Compared to the motor with separate bearings, the motor mount on the output shaft side and the flexible coupling is replaced by

a diaphragm coupling.

Bearingless Motor

The rotor is rigidly connected to the drive pulley by means of a flange connection (Figs. 4 and 5).

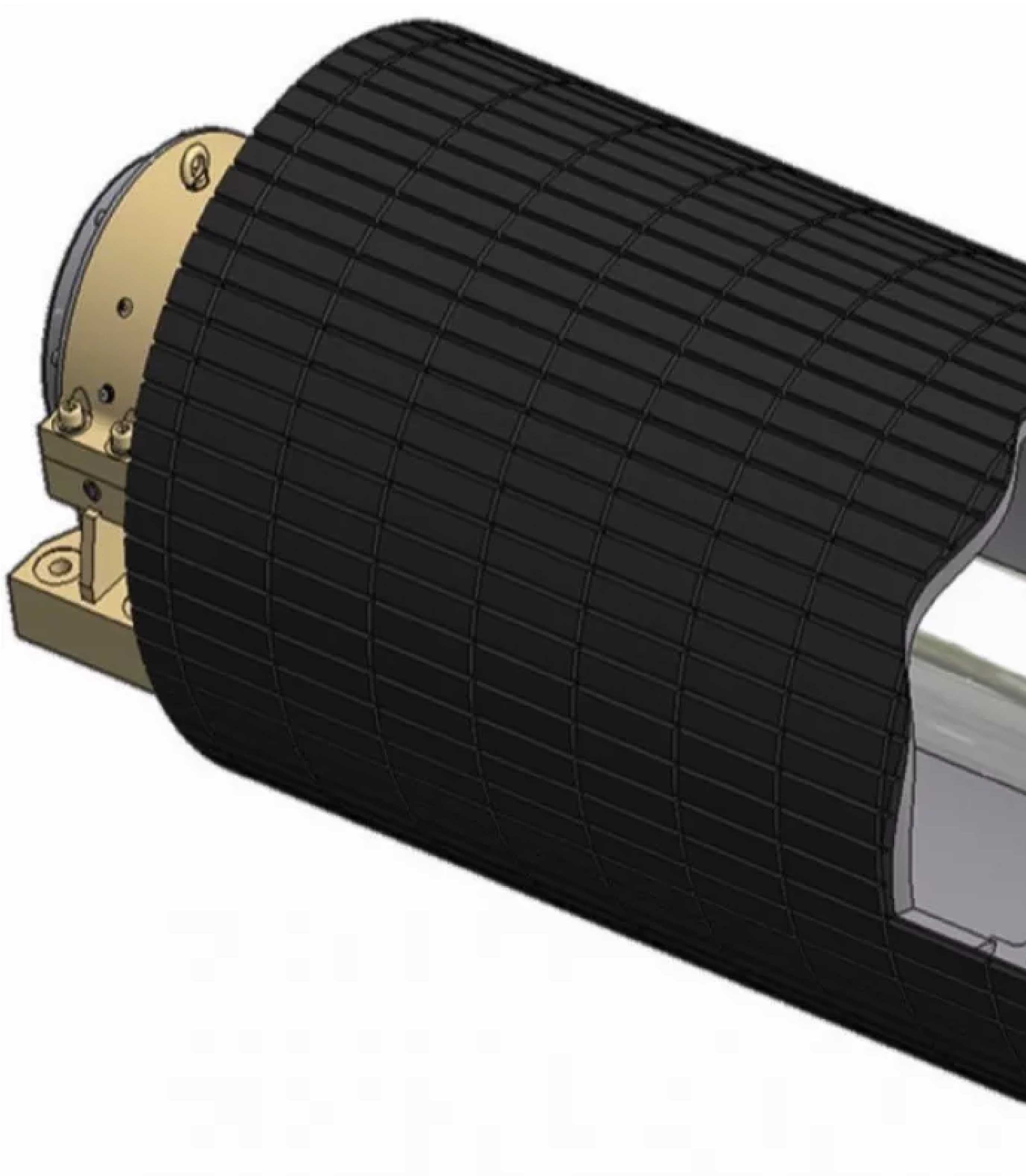

Fig. 4 : Drive pulley with connencting flange for the motors rotor. (Picture: © Takraf)

Compared to the standard layout, an additional criterion is necessary for dimensioning the drive pulley. The deflection of the pulley shaft at the coupling flange may not exceed the close tolerances that result from the permissible deviations in the air gap between rotor and stator. That leads to drive pulley structures with large shaft diameters (see Fig. 1). Since the rigidness of the stator mount determines the tolerances in the motors air gap to the same extent, it is necessary to offer solutions with very limited deformations that also allow a subsequent alignment of the stator during commissioning of the conveyor. Drive realignment would be necessary if a proper belt alignment could be reached by drive pulley readjustment only.

Motor with extra Bearing

For the solution previously described, no motor bearings are needed, neither is a special coupling required for connecting the motor to the drive pulley. A rigid flange connection is sufficient. On the other hand, bearingless motors also have disadvantages, such as:

- Special drive pulley design to decrease shaft deflection
- The motor must be assembled on site, since the rotor first has to be connected with the pulley shaft and the stator is then moved over the rotor. This means that the motor must be disassembled again after factory assembly and completion of test run.
- In case of damage, the motor cannot be disconnected quickly and/or replaced with a spare drive.
- For the load case earthquakes, it is necessary to take into consideration the large (rotor) masses at the cantilevered drive shaft end.

The disadvantages described here with regard to bearingless motors have led to working with ABB to design a motor with separate bearings as an alternative.

Diaphragm Coupling

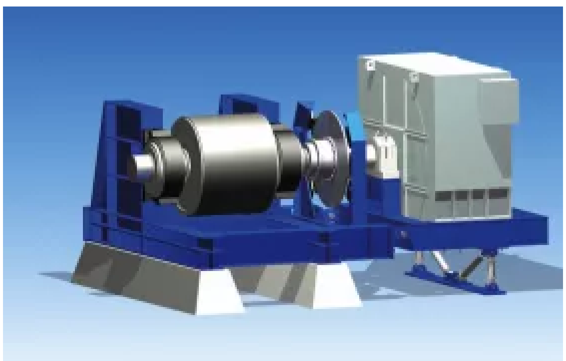

Fig. 6: Motor with seperate bearing, flexible coupling, brake disc, drive pulley and the patent-pending support structure. (Picture: © Takraf)

With regard to the bearing motor previously described, the motor and drive pulley are connected by means of a flexible coupling (Fig. 6). A gear coupling was selected as suitable transfer element for the torque being transferred and the permissible angular deviation of both shafts. For very large motors (6000 kW up to 8000 kW of drive power), geared couplings reach their limits. The drive concept with bearingless motors has resulted in heavy and expensive drive pulleys due to the deflection of the pulley shaft in the area of very large drives.

Based on these disadvantages, a motor concept with a bearing at motor N-end and a diaphragm coupling to connect the rotor with the drive pulley was developed. The diaphragm coupling combines the functions of the bearing at the motor D-End and the geared coupling between rotor and pulley (Fig. 7).

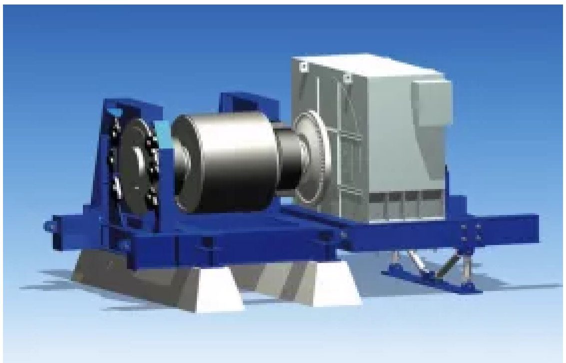

Fig. 7: Motor with seperate bearing, diaphragm coupling (patent pending), brake disc, drive pulley and the patent-pending support structure. (Picture: © Takraf)

To transport the motor, a support structure will be placed on the motor frame, which secures the rotor shaft on the side with the output shaft end. This also provides the option to quickly separate the motor and the drive pulley by opening the coupling in case of an emergency.

Projects

In 2012 Takraf was awarded a contract by the Chilean mine operator Codelco to deliver conveyors with 12 gearless belt drives for the world’s largest underground copper mine (El Teniente). After completion of the conveyor installation, approx. 12000 t/h of copper ore will be transported over a totaldistance of 11.5 km. The drive motors each have an output of 2500 kW. As a result of extensive discussions with the customer, the principle of the motor with separate bearings was implemented for this contract. The commissioning of the first motor is slated for 2014.

Summary

Gearless drives are expanding the service range of drives of belt conveyors. Individual drives with a driving power of up to 8000 kW are possible. Studies on the use of gearless drives of this performance class are currently being carried out in the current projects. When it comes to maintenance and energy efficiency, gearless drives offer advantages compared to the conventional electromechanical solutions. The drive motor can be designed as bearingless, with bearings or with diaphragm coupling. Motor size, site conditions and customer requirements form the basis for the solution that is to be implemented.

A Note from the Editor:

For all statements in this article that refer - directly or indirectly - to the time of publication (for example "new", "now", "present", but also expressions such as "patent pending"), please keep in mind that this article was published in 2014.