More Than a Hundred Years Experience of Mine Hoist

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The first electrically powered mine hoist in Sweden is believed to have been installed at the end of the 1880s or in the beginning of the 1890s. ABB’s (Asea’s) first modest contribution dates back to 1891, when the company supplied a steam engine-driven DC generator with a rating of 60 A, 220 V and a motor of the same size for a mine hoist. The motor was operated with a simple drum controller in combination with a series resistor.

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ABB’s experience of mine hoists covers over a century. Up to 1936 the company concentrated on the drive and control systems for mine hoists, while various engineering firms were responsible for the mechanical parts.

Over the years mine hoists of various types were developed. A major advance occurred in the mid 1940s with the introduction of the Multi-rope Koepe or friction hoist with skips/cages in balance or with counter-weight.

The simple three-phase slippimg induction motor with a secondary resistor bank and, later, liquid resistor bank, as drive system dominated the scene in the early years due to its low cost, reliability and compactness. However, its limited speed control and low efficiency meant that it was only used to drive small mine hoists. Later, the motors were operated and controlled with cam controllers in combination with contactor-operated starting and control resistors and reversing contactors. The early drive motors were coupled to the hoists via belts, but these were replaced later on by precision gearboxes, an ABB speciality for many years. In older mines drivers operated the hoists from control desks set up close to the hoists. Later on, pushbutton operation was introduced for production hoists. A combination of driver and pushbutton operation was also used in smaller mines with a hoist for both men and ore transport.

The variable-speed DC drive based on the Ward-Leonard system provided to be a much improved speed control for mine hoists. ABB indeed supplied such a system as early as 1904. However, the Ward-Leonard system had one main disadvantage, namely its high cost, since three machines were needed. In addition, it did not have such a high efficiency.

Over the years the output of the motors increased in time with the growing payload of the mine hoists and in combination with deeper shafts. Motor outputs of over 4,000 kW were by no means unusual, and hoisting distances could exceed 2,000 metres, as in South African gold mines.

Mercury-arc rectifiers were used to control DC motors during the late 1950s and early 1960s. However, they soon became obsolete due to the entry of the thyristor converter and monitoring systems were introduced in the early 1980s. They included controllers (PLCs) and workstations from the ABB Master Distributed Control System (DCS). In the 1990s similar products from the ABB Advant Open Control System (OCS) gradually replaced the ABB Master products.

New technology for the speed control of AC synchronous motors became available at the end of the 1960s with the launching of initially analogue, later fully digitally controlled cycloconverters. To begin with, cycloconverters were used for mill drives. At the same time, the manufacture of low-speed, high-torque DC motors became increasingly expensive. The manufacturing costs for large AC synchronous motors, on the other hand, were substantially lower. AC cycloconverter drives with synchronous motors for mine hoists consequently started to dominate the scene from the 1980s.

Top-class braking systems have always been of vital importance to the safe operation of mine hoists. The earlier hoists were equipped with shoe brakes, but since 1964 all the mine hoists supplied by ABB are equipped with a hydraulic disc brake system developed by the company. The modern ABB mine hoist system today incorporates many other features ranging from hoist monitoring, constant emergency retardation control, brake disc temperature monitoring to automatic compensation of rope elongation.

ABB’s mine hoist systems of today

ABB Automation systems today supplies a full range of friction and drum hoists. Friction hoists are normally used for shaft depths of up to 2,000 metres and are usually of multirope (up to 10 ropes) design. The diameter of the ropes and the dimensions of the pulley are generally less than for a drum hoist. Furthermore, the tail rope balances the weight of the main ropes. This means that a friction hoist has a low torque requirement.

Drum hoists, both of single- and double-drum types, used in ultra-deep mines, in inclined shafts and for shaft sinking. They are also to be found in shafts, particularly where double winding from several levels is required. Drum winding is sometimes preferred in shafts subject to severe corrosion, since the ropes can be heavily lubricated with an anti-corrosion agent.

A new 4-rope friction hoist driven by a 1500 kW AC synchronous motor controlled by a cycloconverter was commissioned in May 1999 at BHP’s Cannington Mine in Central Queensland, Australia. ABB was responsible for the complete vertical transport system.
The pulley/drum is bolted direct to a forged flange on the shaft. ABB’s mine hoists are ‘homogeneously flexible’, which means that they are rigid where required and flexible where stress concentrations have to be avoided. The pulleys/drums consequently have a relatively low mass and inertia, thus reducing the need for a massive supporting structure. The motor can be coupled either direct to the hoist by shrinking the rotor on to the overhung shaft end, or via a precision gearbox with flexible couplings.

**Hydraulic disc brakes**
Each mine hoist is equipped with a number of disc brake units controlled by a hydraulic system with three different oil release branches to guarantee maximum safety. Flanges separate the brakes and discs from the rope area so as to protect them against contamination. A system for measuring the temperature of the brake discs has become a standard feature.

The state-of-the-art brake control system developed by ABB and fitted so far on more than 25 mine hoists provides controlled retardation. The set retardation rate is maintained irrespective of the load and its direction. This increases the safety margins and lowers the stresses on the equipment.

**Magnetic rope marking**
The MRM magnetic rope marking system, with magnetic marks on the head rope and sensitive detectors mounted by the pulley/drum, is today replacing the traditional shaft limit switches used to synchronize the hoist position control system. The detectors also include diagnostics functions to monitor the strength of the magnetic marks. One major benefit of the MRM system is that it does not require extensive maintenance, as is the case with limit switches.

**Rope oscillation control**
For mine hoists operating in deep shafts ABB has developed a new rope oscillation rope control system, ROC. Its purpose is to reduce the dynamic rope tension in order to increase safety and extend the rope life.

**Mine hoist drives**
ABB is today supplying both DC drives with thyristor converters and AC drives with cycloconverters or converters based on DTC (direct torque control) and IGCT (integrated gate commutated thyristor) technologies. As mentioned earlier, DC drives previously dominated the scene, but digitally controlled AC drives with synchronous machines with their superior characteristics now successfully compete with DC drives in the 3 to 27 MW output range. The ACS 6000 SD synchronous motor drive is the latest drive in the megawatt class to have been developed by ABB. It incorporates several new technologies such as DTC and IGCT power semiconductors.

DTC is an optimized motor control method for AC drives that allows direct control of all the core motor variables. Combined with the benefits of the synchronous motor, it fully implements the capabilities of AC drives. Its response to process changes is extremely fast.

The IGCT, which consists of a redesigned GTO (Gate Turn Off Thyristor), is a high-speed switching device with inherently low losses. The IGCT-based ACS 6000 SD drive system has been specially designed for demanding medium-voltage drive applications such as for mine hoists.

Two of the most significant benefits of DTC in combination with IGCT power semiconductors are the ability to control the power factor and virtually eliminate the lower and medium range of harmonics. Maintaining the power factor at unity, i.e., the drive does not consume any reactive power, dramatically lowers voltage variations on the supply network. In this respect the ACS 6000 SD drive has a significantly improved performance compared with the cycloconverter drive.

Furthermore, the new drive concept virtually eliminates voltage and current harmonics up to the 27th order. A typical mine hoist installation consequently does not require any harmonic filters. Yet another benefit is that the voltage drop caused by the load is greatly reduced. ACS 6000 SD drives can therefore be connected to weaker supply networks. No bulky power factor correction equipment is required either. Other savings relative to cycloconverter drives are fewer transformers, no DC circuit-breaker, smaller footprint, fewer power cables and faster and more accurate speed control.

**Advant hoist monitor system**
The Advant Hoist Monitor System AHM 110 is used to monitor and protect mine hoists of all types. It provides very accurate monitoring of essential parameters such as speed, acceleration, deceleration and position of the conveyance. Furthermore, it operates independently of all other control equipment. AHM 110 initiates an emergency stop in the event of overspeeding or overwinding. A display unit is used to set the hoist parameters and present data logging functions.

**Hoist control system**
The latest generation of ABB’s hoist control system is based on the ABB Advant OCS technology. Adapted to the specific needs of mine hoist applications, this powerful, user-friendly control system is built up around an Advant Controller AC 110, Advant Station 500 Workstation for the HSI (Human-System Interface) and AdvaSoft software. It gives optimal cycle times and production, reduces maintenance and improves the production and maintenance reporting. In addition, it incorporates advanced fault tracing diagnostics and remote diagnostics. ABB has supplied more than 170 microprocessor-based control systems to mines all over the world.

**Global installation base**
ABB Automation Systems’ single- and double drum and friction hoists have been installed in more than 30 countries in every continent around the world. The company has a proven track record as the world’s only major supplier of complete mine hoist installations, i.e., both the electrical and the mechanical parts. Since the early 1990s ABB has supplied more than 550 complete mine hoists, or sets of electrical and control equipment. Today, exports account for more than 90 per cent of the mine hoist business.
ABB Mine Hoists

ABB has delivered more than 600 new mine hoists and undertaken the modernization of hundreds of existing hoisting plants worldwide. Our unique position as the sole supplier of complete mine hoists, both mechanical and electrical, enables us to optimize total solutions for our customers.

With more than 60 years’ experience of producing high performing mine hoists, ABB offers a complete range of hoists including single drum, double drum and friction hoists for use as production or cage hoists or for shaft sinking. Our product program includes:

- Mechanical equipment with high-performance disc brakes
- Shaft equipment such as skips, ropes with attachments and measuring pockets
- Modern DC or AC drive systems
- Advanced digital control and monitoring

ABB Automation

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