

## A powerful retrofit ABB drive retrofits extend life cycle of shovels and draglines



Shovel excavators and draglines are mechanically robust and can have a life cycle of up to 30 years. However, regular upgrades of the electrical equipment are recommended to improve reliability and reduce maintenance costs. Such an upgrade only makes up about 10–12% of the total costs for a new machine — making retrofits a powerful and efficient tool to extend the life cycle of your mining equipment for another 10–15 years.

A large yellow and grey P&H mining machine is shown in operation at a coal mine. The machine is a massive piece of heavy machinery, likely a shovel or dragline, with a large yellow bucket and a grey body. The letters "P & H" are prominently displayed on the side of the machine. The background shows a clear blue sky with some clouds and a rocky landscape. The machine is positioned on a pile of coal, and there are some cables and hoses visible in the foreground.

Boris Rathmann, ABB, Germany, describes how AC drive retrofits for shovels and draglines can be a cost-efficient alternative.

Coal has been the key to a reliable energy supply and has fuelled the world's industrial development over more than a century. A pressing question today concerns the role of coal in power generation in the near and mid-term future. US coal production, for example, increased slightly during 2011 for the second year in a row, rising about 0.4% from its 2010 level, after falling sharply during 2009, according to the US Energy Information Administration (EIA). This made total production for 2011 around 1.1 billion short t (997 million t). Increasing environmental awareness, and the desire to tap into alternative sources, such as shale gas and renewables, has sharpened the problems around coal.

# A POWERFUL RETROFIT

Numerous claims have been made by US mining and power generating companies about the industry struggles to co-operate with the US Environmental Protection Agency (EPA).

Nevertheless, in developed countries such as Germany, coal still remains an important power generating source, accounting for about 43% of electricity generation in 2011. This is in a similar range to North America. In combination with the shutdown of nuclear power plants after the Fukushima disaster in March 2011, the role of the domestic coal-fired power plants has increased. Germany is the top lignite mining country in the world. All of the country's lignite production is used domestically for power generation and is increasingly important for the baseload energy generation.

Does Germany face different environmental and economical challenges than North America, or the rest of the world? Most likely not: the answer lies in technology development and cost-efficient processes. Coal mining will remain a profitable business over a long time period as it was in the past.

In last two decades, state-of-the-art technology developments around the

globe have founded a solid base for the coal mining industry. Highly automated overburden removal systems, coal blending and energy-efficient mining machines are commonly found at large-scale operation and brownfield investments. In particular, the retrofit and upgrade of existing mining equipment is an important market for a turnkey supplier of electrical equipment such as ABB.

### **Electric rope shovel with AC drives**

ABB mining drives have provided benefits for customers of one of the market leaders for electric rope shovels, Joy Global (P&H Mining Equipment). More and more mine operators have decided to employ advanced AC drive technology to achieve a higher level of productivity (10%) and significant energy savings (7%), as evaluated in a comparison between conventional DC shovels and the new AC type 4100 XPC in the Canadian coal industry.

The North American coal industry is looking for the most productive and efficient equipment to attain results for the lowest operational cost. The first 4100 shovels with AC drives began operation in US and Canadian coal mines. A higher performance of AC

drive systems is achieved through the use of a highly efficient motor design, excellent dynamic response time behaviour of the direct torque control (DTC) and the multidrive design with a common DC-bus regenerative motor-to-motor energy usage. Further, the use of individual crowd and propel motion AC drives helps the shovel to quickly achieve an optimal position to the bank and increase the bucket payload. The new AC drives system is more reliable and needs no electrical maintenance for motors.

### **Shovel and dragline motion drives technology**

Over several decades different technologies have been used for motion drives. The most common for shovels is the DC motor with static converter in analogue and digital control.

Today, a typical drives application for shovels is the AC multi-drive concept, in which one supply unit feeds several motor inverters over a common DC bus-bar. The common DC bus allows energy sharing between the motors. Usually a regenerative insulated gate bipolar transistor-based (IGBT-based) supply unit is used, which enables the return of excessive braking energy back to the grid. Regenerative VFD supply units usually have a better power factor and lower total harmonic distortion (THD) levels. In weak grid conditions the drive is also better protected against voltage dips, or even short blackouts. The modern IGBT supply units have an adjustable leading or lagging power factor, and can be used for reactive power compensation.

For draglines, motor-generator sets have been the most popular drive systems and new draglines are still delivered with motor-generator sets. The majority of the operational draglines were built between 1960 and 1990, with Ward-Leonard motor-generator sets and DC motion motors. New draglines are now offered with conventional or gearless AC drive systems. The advantages with new motion drive solutions are almost maintenance-free AC motors, and higher efficiency of the overall drive system, as well as better drive controls and diagnostics compared to DC



**Electric rope shovel operating with ABB ACS800 multi-drive.**



ABB ACS800 drives module.

drives. The higher overall availability of the dragline with an AC drive system will provide significant productivity improvements to the mine operation and the operating cost of the machine.

### AC drives retrofit extending the shovel life cycle

Rope shovel excavators are mechanically robust and can have a life cycle of up to 30 years – around two to three times the life cycle of a hydraulic mining shovel. After a certain period of operation, it is recommended to upgrade the electrical equipment to improve reliability and reduce maintenance costs. Decreasing availability, obsolete technology and increasing difficulty in acquiring the necessary spare parts make many users think about alternatives. The capital costs of the entire electrical equipment is about 10 – 12% of a new rope shovel. That means a retrofit of an existing shovel can be an efficient way to extend the life cycle for another 10 – 15 years. Usually, it requires a 5 – 6 week period to replace the electrical equipment, including commissioning. Today, most operators appreciate the advantages of AC technology because of a robust motor and reliable power electronic with digital drives control.

An ABB order in June 2012 for a shovel AC retrofit in co-operation with Joy Global MinePro Services to

Drummond Coal underlines the need for upgrades in the coal industry. This BE395B shovel was built in 1987 and is planned to be in operation for at least another 10 years. This is an example in which the operator is convinced that a retrofit can be a cost-efficient alternative to a new shovel.

In addition to the successful AC technology applications, ABB has equipped two smaller shovels with modern DCS800 DC converters with reactive power compensation systems at a quarry in Germany. The upgrade was necessary due to frequent unscheduled downtime and to improve the functional reliability and safety of the dated analog electrical system. The new fully-digital converter and new drive control have helped to provide a high degree of functional reliability and reduce overall maintenance costs. Torque control and a backlash protection system for the new drives also helped to reduce the stress factors affecting the machine during operation. With the installed AC reactive power compensation, based upon the ACS800 AC drive, the high surge current of the DC load could be reduced by 25%, further optimising the drive system solution. After a direct comparison of the new shovel with the conventional motor-generator-set solution, a measured energy savings of about 15% was realised. This was calculated using 5000 operating hours/year as a basis with a resultant cost savings of US\$ 17,500/year for this application (5 m<sup>3</sup> shovel and an industry price of US\$ 0.08/kWh).

For dragline retrofits the situation is similar. An upgrade of an existing machine can be cost-effective and would be available for a short-term mine planning consideration. A new dragline excavator needs a lead time of about two years from the planning to the startup and often requires investment approval at the board level. For that reason, in the North American coal mining industry various tenders have been offered in 2012 for dragline retrofits that focus AC motion drives. ABB offers recent experience in this area from a number of AC retrofits for continuous mining machines, and from

two draglines equipped with AC drives.

### Service and life cycle management

The mining industries face a common goal of maximising their production output at the lowest possible operational costs, with a focus on safety. Increasing uptime requires proper equipment maintenance to ensure the optimum lifetime and performance. This requires a professional engineered and predictive approach for service from the beginning of the equipment's life cycle or after certain operational period to optimise mining operation.

An available system service from ABB is designed to be performed onsite as simply a diagnostic audit of the mining system and has value in measuring the process. With this service, the company analyses the performance of the system and identifies the relevant key performance indicators (KPIs), which results in a benchmark study. This study will be the basis from which to value the financial impact and to consider measures to improve the system. The components that make up a system service are designed to capture opportunities that impact return on investment (ROI) to the operator. The ROI portion attempts to quantify the performance gap in terms of financial return to a specific measure. For this analysis ABB, together with the University RWTH Aachen, developed a Payback Calculator for shovel and dragline applications. After the evaluation of the payback time by the operator, ABB will offer service solutions with an implementation plan.

ABB follows a four-phase model for product life cycle management:

- Active.
- Classic.
- Limited.
- Obsolete.

The company can provide a customised service concept, which covers different areas from global product support to life cycle management, specific operator training or full service concepts. 



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