Energy efficiency

Energy efficiency in industry is a priority around the world. A significant indirect benefit is CO_2 reduction: This is of importance in the light of global warming and the Kyoto protocol. The following short articles give an overview of several typical applications in industry where drives technology in combination with electrical motors result in energy savings and CO_2 reduction.

As brass as you like

With an estimated 65% of industrial electrical energy used by electric motors, it is no wonder major energy users in industry increasingly see energy reduction as a key to increasing their profitability and competitiveness.

Central Electrical, one of ABB's channel partners in the UK, carried out an energy audit on the filtration plants belonging to Boliden MKM (a leading manufacturer of brass and copper products) by measuring the energy used during a typical working week. The audit mainly covered the fume extraction filter plant for the brass casting process, which consists of two Luhrfilter filtration plants, one with a 250 kW fan and the other with three 132 kW fans. The airflow from the fans was controlled by using dampers as restrictors.

The results pointed to potential energy savings with ABB drives of at least £25,000 ($44,650) a year on a 250 kW fan, and £15,000 ($27,300) a year for each of three smaller fans – a saving of £70,000 ($127,300) a year and a payback period of just 9 months. In any case, the total savings achieved for the installation proved to be much higher, some £130,000 ($236,500) a figure verified by Boliden's own energy measurement system.

Ian Davey, Engineering Manager for Boliden, outlined the problems caused by the old system: "The orifice dampers employed had to be closed to start the motors and then gradually opened to the right position for operation. This was a complex method of control that led to considerable energy loss in the system. As we have a variable rather than a fixed load, we decided to employ variable speed drives to regulate the speed of the fans."

It took only two months to replace the old damper system with ABB variable-speed drives and since then estimated energy savings (to date) are in the region of 3,250,000 kWh (assuming 4 pence per kWh electricity price).

Fitting the drives also had other benefits besides energy saving. The swarf drying plant is served by three 132 kW extraction fans. A pressure transducer, mounted in the ducting, feeds information back to each variable speed drive. This not only controls the drive's operating parameters but it also tackles environmental issues by helping to control emissions. In fact, avoided CO_2 emissions amount to approximately 1,625 tonnes.

Under pressure

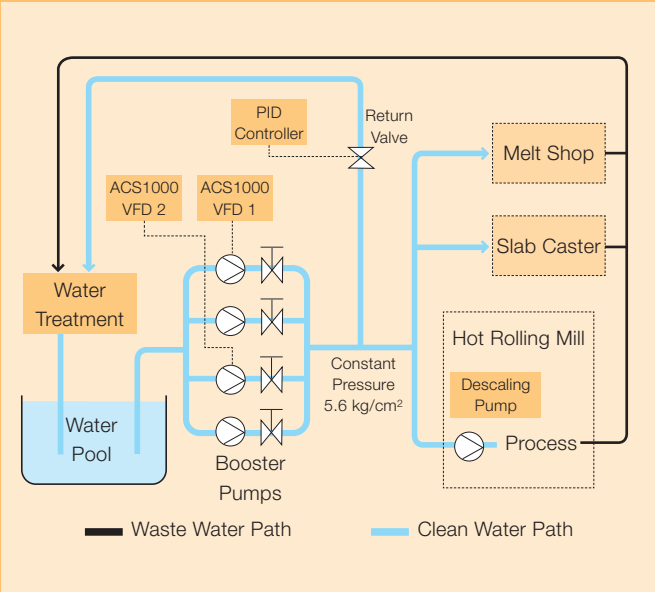
The use of variable speed drives for flow and pressure control of electric motors results in very definite energy and cost savings. A pump, controlled by a variable speed drive, running at half speed consumes only about one-eighth of the energy compared to one running at full speed!

De-scaling pumps in a hot-rolling mill are used to remove scale from the surface of hot steel. They work by taking the low pressure water from the water supply plant and creating the high-pressure water that is sprayed onto the surface of the hot steel, which in turn removes the scale. These pumps are placed before the mill stand and operate when steel passes through the rolling mill. It is only during this phase that the high-pressure water is needed.

To regulate the pressure of the water fed to the de-scaling pumps, a Taiwanese steel company used a mechanical return (bypass) valve controlled by an external PID controller. When peak pressure was required, the return valve was closed and the maximum amount of water was fed to the de-scaling pumps. When de-scaling was not required, the return valve was opened to reduce the water supply. But because the system had fixed-speed booster pumps, they operated at full speed irrespective of the water pressure needed. Because of this, huge amounts of energy were being totally wasted. A solution was

needed whereby the speed of the motor was reduced so that no more energy than necessary was consumed during peak pressure times.

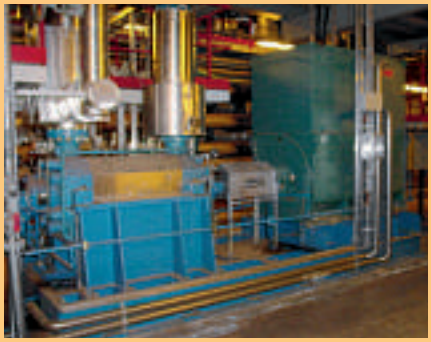
The solution came in the form of ABB's ACS1000 variable speed drives which were retrofitted to the fixed speed booster pump motors. This means that high-pressure water is now supplied only when needed. In addition, the use of drives makes the system response faster than a traditional system with return valves. This stabilizes the water pressure bringing improved steel quality. On top of this, maintenance costs are lower and product quality has improved considerably.



Energy and water costs have been reduced significantly: estimated energy savings (to date) are in the region of 2,930,000 kWh; estimated annual water savings amount to approximately 65,000 tonnes; and CO_2 emissions have been cut by about 1,465 tonnes.

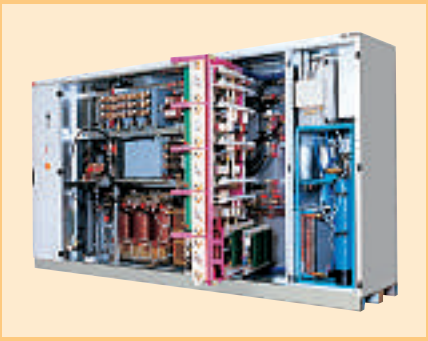
Increasing generation capacity

One way of saving money is by saving energy. And the rewards are not too bad either.



Kainuun Voima Oy's 240 MW CHP (Combined Heat and Power) plant is located in Kajaani, Finland. In 2003, ABB delivered its medium voltage drive, the ACS1000, for a new feedwater pump application in the plant.

Kainuun Voima's criterion for energy-efficiency investments is that the payback calculation has to indicate a full return on investment in less than two years. That being the case, since its installment, Kainuun Voima estimates that the ACS1000 has saved about 1 GWh of energy annually (enough for 50 electrically-heated or 200 centrally-heated households) and reduced CO_2 emissions by about 500 tonnes per year. On top of this, the reduction in operating costs has more than justified the company's investment in electrical variable speed drives.
The Kyoto protocol took effect in the middle of February and since then, spot trading of CO_2 emissions has been picking up. Kainuun Voima's energy efficiency improvement scheme recently qualified for investment support from the Ministry of Trade and Industry.



Impressive compressor functions

ABB's ACS800 drive and custom software is a unique solution when it comes to energy savings and operation efficiency in screw compressors.

St. Louis-based Curtis-Toledo Inc. is a 150-year-old OEM of industrial air compressors (in the range 5–300 hp) used to power equipment and operations in a variety of applications and industries.

With energy savings a top priority, Curtis-Toledo wanted to upgrade its screw compressors with adjustable-speed drives to provide and control airflow supplies in direct response and proportion to real-time operating (load) conditions. To satisfy the company's needs for energy efficiency and ease of use, ABB created a unique control package: the ABB ACS800 drive was built into the compressor and coupled with customized software that controls the system pressure, air delivery, oil temperature and duty cycle directly from the drive.

This innovative approach eliminated separate logic controllers and uses the ACS800 drive to control the speed of the motor. At the same time, its processing power and extensive I/O act like a traditional programmable logic controller.

With a drive built into the compressor as an integral part of the machine, the compressors operate at greater efficiency. This includes matching air vol-

ume to demand as the variable-speed slows the motor down when air demand decreases. Software control enables the drive to regulate and change speed to match the exact air demands from the plant or process.

The ABB drive software was designed to include a formula that continuously calculates the energy savings so the end user can see the dollar savings on demand by viewing a touch screen.

"This whole application is about saving energy, so having a touch screen that displays the calculated energy savings as the machine is running is the biggest benefit, followed by its ability to monitor the working conditions of the compressor," says Jerry Elson, national sales manager for Curtis-Toledo.

End users can expect annual energy cost savings with a 12 to 18 month return on investment on the drive.

With a 75 kW machine running 5000 hours per year, energy savings of about 200,000 kWh (50 percent) have been recorded. This figure may be exceeded depending on the air demands of the facility. Avoided CO_2 emissions have amounted to 100 tonnes.

Wheels of steel turn energy into gold

Over 1,000 MWh of energy is being saved each year at Magnetto-Topy's steel wheel manufacturing plant in Coventry following the installation of seven ABB drives.

Magnetto-Topy's outstanding energy saving, which translates into 500 tonnes of avoided CO_2 emissions, was achieved with a £23,000 investment that will provide pay back in just over one year. In addition, the pump noise has been significantly reduced and this will help the former Dunlop company meet new health and safety levels set at 80 dbA!

Four of the drives, rated from 37 to 55 kW, are used on water pumps within four cooling towers. Two 37 kW drives are used on filtration paint line pumps within the company's wheel paint line and a further 37 kW drive controls a compressor house pump.

The cooling tower drives have replaced star-delta switching which was used to turn the pumps on and off. With this arrangement, the pumps ran at full speed (on 50 Hz) regardless of production needs. Now Magnetto-Topy is able to reduce the running speed on one pump, rated at 55 kW, to 35 Hz, resulting in a 53 percent energy saving. On three other pumps the running speed has been reduced to between 40 to 45 Hz, reducing energy consumption by between 33 percent and 46 percent.

Pump house noise is reduced by an average of 10 percent by operating the drive at a higher switching frequency. Using this switching frequency, the motors are perceived to be operating silently, because the sensitivity of human hearing decreases rapidly above 15 kHz.

Magnetto-Topy is the UK's only producer of steel wheels and it presently produces up to 100,000 wheels each week. Dave Pound, Operations Manager, says "the electricity costs alone needed to make each wheel is estimated at 14p. The energy reduction saves at least 1p. This may not sound much, but when we are producing so many wheels and with pressure on to reduce overheads, then 1p per wheel mounts up to a tidy sum."

One of the overhead costs under scrutiny is the maintenance budget.

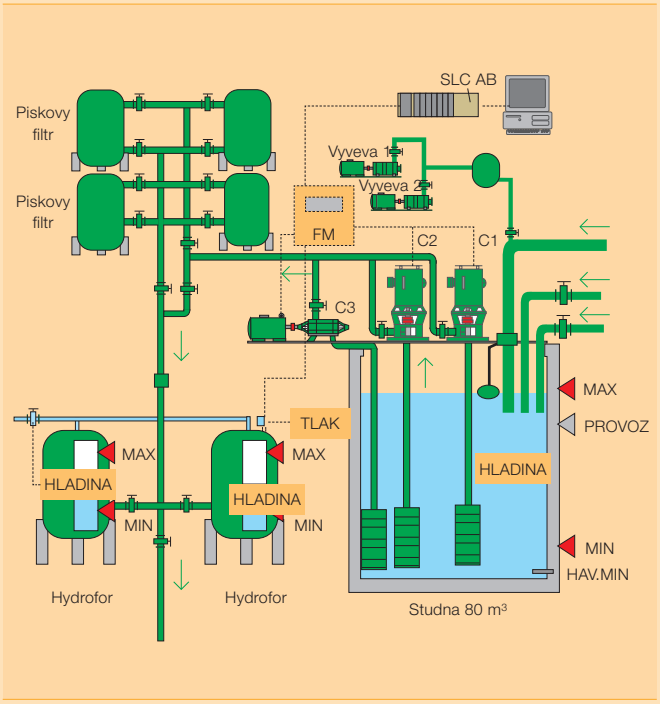
"Apart from energy saving, the drives bring much greater reliability to our process. Star-delta starting stresses the motor, whereas the smooth start of variable speed drives has a direct impact on maintenance costs," says Phil Smith, Maintenance Services Administrator. "Pumps will run longer as they are running slower and with less vibration. The reliability of the drives now means I rarely go near the system."

Keeping up to date with the demands of the environmental system, ISO 14001 is a key factor in choosing variable speed drives. In addition, Magnetto-Topy aims to claim its Climate Change Levy (CCL) allowance, for which it needs a 10 percent saving over 10 years. "We are on target to achieve it this year, which means we won't have to buy carbon permits" says Pound.

Paul Stafford, Director of Drives at Sentridge (ABB Drives Alliance partner) concludes: "In a time of economic uncertainty, costs saving procedures are usually implemented on the factory floor, therefore why not reduce long-term costs through energy conservation? Installing a variable speed drive not only lowers energy bills and pays for itself in about a year in our case, but it also conserves the valuable energy needed on a daily basis".

Pump it up

An ABB AC drive has been used to upgrade the water supply system at a pharmaceuticals plant in the Czech Republic. The upgrade has produced estimated annual savings of around € 100,000 through reduced energy consumption and major improvements in the reliability and operating lifetime of electrical and mechanical components.



The pumping station at the plant has three pumps: two 70 liters per second and one 50 liters per second. The supply system pipework has a maximum capacity of 70 liters per second. Prior to the upgrade, the pumps were used in on/off mode with control provided by two pressure switches, with a minimum of 300 kPa and maximum of 600 kPa. Only one pump – selected manually – was run at a time. The system was subject to very frequent start and stop sequences (the maximum time between start and stop being less than 10 minutes) resulting in damaged motor windings, burnt-out contactors, and deterioration of pipe seals.

The upgrade project, implemented in close co-operation with ABB's local Drives Alliance Partner, involved replacing the existing direct motor control with an ABB variable speed drive.

Following the upgrade, one of the 70 liters per second pumps is kept in reserve. Of the two pumps controlled by the drive's PFC macro, the second 70 liters per second pump is run as a variable speed unit, while the 50 liters per second pump is run at constant speed. Overall control and monitoring is performed by an SLC 500 A–B PLC unit. The InTouch software provides a screen display of the system's operation. All the features of the PFC macro, including the sleep function and autochanging, are utilized, as is the drive's PID controller.

Operation is now fully automatic and parameters can be set and changed quickly and easily. The pressure in the system is held constant, there has been a significant reduction in vibration and noise levels, and reliability has improved dramatically. At the same time wear and tear has been minimized.

The use of the AC drive has also provided considerable financial benefits. In the six months before the project, an average of 0.417 kWh of electricity was consumed for every cubic meter of water pumped. This figure fell to 0.299 kWh/m³ (a fall of 28.3 percent) for the six months after completion of the project. Total electricity savings in the first year have been estimated at around m 3,800 or 96,000 kWh, and CO_2 emissions are down by 48 tonnes.

The indirect savings resulting from the upgrade are even greater – in the case of one end user, about m 100,000 per year. This figure is a result of reliable motor operation, significantly reduced contactor failure rate, increased reliability in the pipe system and other components, and reduced maintenance and servicing costs.

Triple punch

What do you get if you combine an AC motor, drive, and load cell from ABB? The answer is a new era of electronic, integrated web speed and tension control for small-horsepower unwind applications.

The products and expertise of three ABB business units – Motors, Drives and Load Cells/Tension Control – have been combined so that an AC motor can be used to replace a traditional mechanical-brake-and-air-supply system. For any processor unwinding paper, film or foil, this solution is a quantum leap in operating, maintenance and cost benefits.

According to Bob Sarnelli, product manager, ABB Inc., Automation Technologies, Web Tension Products, "All the mechanical considerations of keeping an air-powered brake, and the air line and air supply to them functioning are gone. In addition, the electronic control replacing it erases all those mechanical headaches and provides superior unwinder control."

The function of the brake is to control the tension of the unwind material into the process. Most configurations use load-cell systems to monitor the web tension, and a setpoint controller that feeds the difference between the desired unwind tension (setpoint) and the measured tension from the load cells to the air-brake control. Air brakes, however, and their air-supply system have many application shortcomings and invariably become problematic as they age.

Since the basic operation of the brake is to apply holdback force (torque), why not use a motor in a mode that requires force (torque) to turn it? The idea of using a motor as a brake is not entirely new and has been used successfully in unwinding applications, but

mostly in large applications that require high horsepower, ie, above 25hp, such as paper manufacturing where the rolls are extremely large.

Historically, the biggest obstacle to using a motor as a brake on small-horsepower unwinder applications has been cost. "But with all the recent leaps Variable Frequency AC Drive (VFD) technology has made, the AC drive/motor solution now provides performance and control superior to the traditional DC installations," notes Chuck Hollis, manager of system integrator sales, ABB LV Drives, New Berlin, Wisconsin.

Because AC drives and motors have continued to add performance features while reducing price per horsepower, AC drive/motor solutions have, according to Hollis, become "extremely competitive with mechanical brakes."

The performance and cost advantages of using an AC motor-brake system have been proven in a plastic film application. IR Industries in the state of New York had a two-roll unwinder with two, ten-year old mechanical air brakes and a host of repeating problems. Product quality and production were suffering. Rather than replace the mechanical brakes with a new, more modern mechanical brake, ABB was contracted to install a 5hp AC four-pole motor, a 4:1 gear reducer, and an ABB ACS800 Direct Torque Control (DTC) drive with built-in flux braking.

Upgrading without investing

In the city of Turku (Finland) many heating, ventilation, and air-conditioning (HVAC) systems in many of the city's municipal buildings have been upgraded using an Energy Saving Company (ESCO). In 2004, the HVAC systems in the office of the city's harbor were also revamped but this time, ABB technology was fundamental to the project's success.

Also called "performance contracting" or "third-party financing", an Energy Service Company (ESCO) develops, installs and finances projects designed to improve the energy efficiency and maintenance cost for facilities over a several-year period. YIT Building Systems is such a company and was contracted to do the HVAC projects in Turku. The city itself is not investing anything into energy efficiency, but is paying a service fee – in proportion to the energy cost savings achieved – to YIT.

YIT modernized the air-conditioning system of the city's harbor office in 2004. Many system improvements were done, but central to energy efficiency improvement was the decision to install ABB drives and eff1-rated motors to the air handling units. The drives enable the ventilation fans to operate at a suitable air flow based on demand, and eff1 motors guarantee high electrical-to-mechanical power conversion efficiency.

The drives not only save electrical power in part load ventilation conditions, but they also allow for substantial heating energy savings. This becomes possible because the office's exhaust fan can now be operated at the smallest capacity needed for any situation. During the first five months of the operation, YIT Building Systems recorded a thermal energy saving of 97,865 kWh (234,900 kWh over a 12 month period) which represents a 40 percent saving in heating costs. Corresponding CO_2 emissions were reduced by 67.2 tonnes.

Drinking and "driving" in Bangkok

Supplying a city of 11 million people with clean water is no easy task. The fluctuating demand must be met uncompromisingly and equipment must perform as expected. ABB technology is keeping the water flowing.

MWA (Metropolitan Water Works Authority), a Thai state enterprise charged with operating the world's biggest tap water treatment plant, supplies the drinking water for Bangkok's 11 million plus citizens.

It has a total treatment capacity of 4.3 million cubic meters per day. The treated water is distributed by three transmission pumping stations and 20 distribution pumping stations through a 20,000 km pipeline network.

Most of MWA's pumping stations were equipped with eddy current coupling drives that controlled the speed of the treatment plant's water pumps. Even though they operated with varying speed, MWA had excess energy losses of almost 15–30 percent because of the outdated technology. As electricity costs amount to almost 50 percent of their production cost, MWA was looking for ways to increase the efficiency of their pumping stations.

It was decided to replace the coupling drives with ABB's ACS 1000 medium voltage drives and by doing this, the treatment plant's system efficiency has increased by 15–30 percent (depending on the required operating speed). In the first year of their operation, the first two ABB drives have contributed more than $120,000 to energy cost savings. This figure translates into monthly energy savings of approximately 180,000 kWh and does not take into account any additional savings from improved maintenance. CO_2 emissions have been reduced by about 90,000 kg per month.

Other practical plusses include a more flexible pump operation, increased lifetime of motors and pumps, easier maintenance and full automatic control.

"Driving" through the snow

With an objective of reducing power consumption and motor maintenance, the two longest AC-powered ski-lifts in the U.S, Breckenridge Ski Resort in Colorado and Sugarbush Resort in Vermont, have installed 900 hp and 700 hp fully regenerative AC drives and AC motors from ABB for the resorts' Independence and Green Mountain Express lifts, respectively.

Breckenridge's lift is a 7,150-feet-long (2,180 m) detachable six-pack; the top-powered Green Mountain Express runs to 6,250 feet (1,905 m), with a vertical rise of 1,500 feet. Both lifts were built by Leitner-Poma. According to Jason Lisai, director of planning for Sugarbush, "When the decision was made to upgrade the ski-lift systems, we wanted to use the best available technology."

Drives technology is certainly impressive when you consider that regenerative drives have the ability to use the energy a motor produces when it is being turned, rather than being required to turn the load it is connected to.

The IGBT-based (Integrated Gate Bipolar Transistor) switch construction of a regenerative AC drives' front end, combined with ABB's unique LCL (Lower Control Limit) filter, enables lifts to run at full power, in 80 percent "brownout" conditions! This ride-through ability means that even when there's a dramatic short-term reduction in voltage from the utility grid, the drive sustains full power to the motor and lift so that operation is not interrupted.

Harmonic mitigation is built into ABB's regenerative drives via technology that eliminates the need for large, expensive, custom "mountain wide" tuned harmonic-trap filters. The harmonics generated by a typical DC drive would be approximately seven times those generated by ABB's regenerative AC drive with its unique LCL filter. This is a result of the AC drive's ability, as an active filter, to shape the current sinusoidally.

"We expect the lift to operate at around 95 percent efficiency as opposed to DC systems where we normally expect 91 percent," says Gabe Arnold, CEO project manager for Efficiency Vermont, the state's utility watchdog reviewing the Sugarbush AC drive system. That difference should lead to savings of around 25,000 kWh per season. With the reduced power consumption an AC drive/motor combination yields combined with the fact that an AC motor is virtually maintenance free, this, according to Tom Clink of Leitner-Poma, "makes a very strong case that an AC drive is the environmentally sound way to go."