Motors and drives for improving energy efficiency

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Today industry and commerce faces an energy challenge. Pressure to reduce energy consumption and to provide security of power is placed on supplies from governments, consumers, legislators and shareholders alike.

These pressures emanate from a background of ever-rising energy prices. As a result, industry and consumers demand more energy efficient products. ABB continuously improves the efficiency of its motors and drives to fulfil these requirements.

Improved efficiency key to energy goals[1]

The world’s demand for energy is rising steadily (Fig. 1). Today, it is nearly twice what it was 30 years ago. By 2030, it may have risen by over 50% again, according to estimates by the International Energy Agency (IEA), who estimates that global consumption of electricity will grow nearly twice as fast as the energy demand overall and that it will almost double by 2030. Industry consumes about 42% of all electricity generated, according to the IEA. The most energy-intensive industries are cement, chemical, iron and steel.

The energy saving potential in industry’s motor-driven applications alone are enormous: hundreds of millions of electric motors driving machines, compressors, fans, pumps or conveyors in virtually every sector account for about 67% of all the electricity that industry uses. More than 90% of industrial motors either cannot adjust their power consumption or use very crude methods to do so. Many motors continuously run at full speed, regardless of the actual output required. In many applications, energy use can be cut to one eighth just by reducing the motor speed by half.

The most immediate, cost-effective and practical way to address the energy challenge is to grasp the opportunities for energy reduction that comes from using energy more efficiently with available and proven technology. Drives, motors and other related technologies can help lower energy use, either by reducing power consumption and losses, improving productivity through better management of equipment.

Reduce energy, increase productivity and safeguard quality

There is great potential to save energy and costs in industry. Nearly 70% of all electrical energy consumed by industry is used by the millions of electrical motors installed worldwide. Every year, several more millions of motors are added. These motors are the workhorses of industry, driving machines, compressors, fans, pumps and conveyors in virtually all industrial sectors. Not only are pumps and fans numerous, they also have the greatest energy saving potential. Therefore, targeting pump and fan applications is a great way to begin an energy saving initiative. ABB supplies virtually every industry with a broad range of electric motors and drives to reduce energy consumption, increase productivity and safeguard quality.

One of the quickest ways for industries and utilities to lower energy consumption and therefore reduce their bills is to employ high efficiency motors and drives. In many instances the return on investment can be less than two years and in some cases within months. While such payback can have a significant effect on the profitability of an organisation, other benefits come...
from contributing to the environmental objectives of the community. Installing high efficiency motors and drives not only reduces energy costs but can significantly contribute to improving process control and reliability, increasing production capacity, reducing maintenance costs and lowering reactive power.

Safe, reliable and efficient motors [1]

ABB has long supported the need for efficiency in motors, and high efficiency products, and has a full range of motors in IE2 class; premium efficiency motors in IE3 class; and super premium motors in IE4 class. IEC/EN 60034-2-1 specifies new rules concerning efficiency testing methods and IEC 60034-30 defines new efficiency classes IE1, IE2 and IE3 for DOL (Direct-On-Line) motors. In addition, standard IEC/EN 60034-31 defines super premium efficiency class IE4 for both DOL and driven motors (Fig. 2). These standards will provide major energy and cost savings to industrial and commercial motor users, while helping to moderate the growth in the world’s electricity demand.

More accurate measuring of motor efficiency benefits both manufacturers and end-users. A level playing field is introduced, enabling manufacturers to compete on equal terms and users to easily compare the efficiency of different motors. In addition, emissions will be reduced significantly, if the majority of motor manufacturers take steps to improve the efficiency of their motors.

ABB has calculated the efficiency values under the efficiency testing standard IEC 60034-2-1: 2007 according to the indirect method, with additional losses determined from measuring. Comprehensive ranges of low voltage motors are available (Fig. 3), ranging from 0,055 to 1000 kW. In addition to low voltage standard motor ranges, the company also offers a wide range of motors and generators for hazardous areas, marine and special applications as well as high voltage and synchronous motors and generators up to 72 MW.

Further benefits of using high efficiency motors include:
- Reduced maintenance through cooler running
- Reduced bearing and winding temperatures thereby extending the lubrication intervals and increasing motors useful life
- Very stiff basic structure achieved by optimisation of cutting-edge design, quality materials and advanced manufacturing techniques
- Less noise generated and subjected to lower mechanical stresses.

Energy-saving drives for every need

Drives reduce the output of an application, such as a pump or a fan, by controlling the speed of the motor, ensuring it runs no faster than it needs. Many motors are oversized to cope with a maximum demand that rarely or never occurs. Using a drive, as seen in Fig. 4, the motor speed is brought down to match the actual demand from the application. This could result in energy consumption being cut by 50% and in extreme cases by as much as 90%.

When other control methods are used, such as dampers, vanes or valves, the motor runs at full speed and the flow of the output is mechanically restricted. For instance, the flow through a pipeline may be reduced by a valve. This is wasteful, because the motor keeps running at its nominal speed regardless of the demand. The pump delivers maximum output and the excess is reduced at the valve, where the surplus energy is wasted through friction. The relationship between a pump or fan’s speed and its energy need is known as the cube law, because the demand for power increases with the cube of the speed.

This means that a small increase in speed requires a lot more power, but also that a modest speed reduction can give significant energy savings. A pump or a fan running at half speed consumes only one eighth of the power compared to one running at full speed. In addition to the energy savings, the drive delivers accurate control and less mechanical wear, reducing maintenance and extending the life expectancy of the system. Payback is often less than six months on energy alone. Not only does the drive offer substantial potential energy savings, but the savings are also easy to control and to quantify.

Many of ABB’s drives have built-in energy calculators to monitor energy used and energy saved by the motor in kWh, Rand and CO₂. Energy saving calculation tools which are used to make a reasonably accurate estimate of the potential savings of an application are also available. The estimates are used to check the viability of installing a drive against other alternatives (see Fig. 5). The drives built-in energy calculators show actual results that can be compared with the estimates of the
“On average, an additional dollar invested in more efficient electrical equipment, appliances and buildings avoids more than two dollars in investment in electricity supply.” (IEA’s World Energy Outlook, Nov. 2006, pg. 43)

Fast and efficient energy appraisal

ABB has devised a simple and methodical energy appraisal process that presents the energy saving potential of selected applications to the end-users. The starting point for a successful energy appraisal is to identify applications where energy can be saved immediately by using ABB drives and motors.

An energy appraisal is normally carried out by an engineer or an authorised local channel partner who can identify relevant applications that will generate energy saving results. This identification helps the end-user target an investment so that it generates the highest possible savings and delivers the best return on investment. ABB’s experience is captured in its energy appraisal scheme. There are six steps to an efficient energy appraisal:

1. Outlining the appraisal scope
2. Monitoring and data collection
3. Data analysis
4. Recommendations
5. Implementation
6. Verification and follow-up.

Outlining the appraisal’s scope

An engineer or an authorised channel partner visits the end-user to get an understanding of their facility. This includes location of the applications, an inventory of motors, any health and safety restrictions as well as anything unusual that might affect the energy profile. Energy appraisals are most suitable for processes with variable torque applications that obey the cube law, running continuously and where flow is controlled by a mechanical means such as valves or dampers. This is where the savings from installing a drive really start to look good compared to the investment cost.

Monitoring and data collection

During a walk around the facility, the engineer will spot typical applications that may be running inefficiently. The engineer looks not only at fixed speed motors but also any drives currently used, to see if the application is running at maximum efficiency. The selected applications may be monitored in order to accurately determine which applications are consuming the most energy. If this stage is necessary then it may be performed over a seven-day period, to gain a complete picture of the plant’s typical energy use.

Data analysis

Following the collection of the data, the findings are analysed and potential savings identified using dedicated software. The findings are methodically presented, with tables and graphs being created to help identify where savings are likely to arise. The data available includes an estimation of present energy usage, areas of potential savings, payback time if an investment is made in drives and/or motors, carbon dioxide emission reduction, along with many other key facts and analysis.

Recommendations

An action plan is prepared, usually comprising a report and a detailed engineer’s report, highlighting applications that can save the most. The figures are normally translated into monthly savings, with detailed recommendations for fitting drives or motors. Often the recommendations will show that drives can provide excellent savings in particular applications. The report also shows the expected payback time on fitting new equipment.

Implementation

Using the recommendations from the energy appraisal, the company identifies the correct drive and motor for the respective application. In many instances, it can help with the installation and start-up or commissioning of the drive and motor. This includes setting the correct parameters to ensure that the drive or motor is operating at its optimum energy efficiency.

Verification and follow-up

Once new equipment is fitted, it is normal to track the actual savings against the predictions shown in the engineer’s report. This will also help justify the investment in drives and electric motors. Life cycle services provided to ensure that the drive or motor is looked after throughout its working life.

Life cycle services for improving energy efficiency [1]

For a high efficiency motor and a drive to maintain their energy saving potential
it is important that they are looked after throughout their life cycle. To make sure this happens, a series of energy-related services and tools has been devised that can be used throughout the entire life cycle value chain.

Pre-purchase
Before purchasing a drive and motor, ABB offers an energy appraisal to determine which applications can benefit from the use of drives and energy efficient motors. Given that power consumption savings of 50% can be made by reducing the motor speed by just 20%, and with payback times as short as six months, it's worthwhile considering an energy appraisal. Free energy saving calculation tools, FanSave (Fig. 6), PumpSave (Fig. 7) and EffSave (Fig. 8), can be used to quickly calculate energy savings.

Installation and commissioning
For fast and efficient drive and motor commissioning, ABB offers a professional commissioning service. Company certified engineers adjust the drive parameters to meet the precise demands of the application. All start-up information with process parameters are saved, should the engineer need to recall any information at a later date.

Operation and maintenance
A maintenance assessment carried out by the company or a channel partner provides the foundation for developing a long-term drive and motor maintenance and improvement plan. The purpose of the assessment is to define measures to be taken for lowering operational costs, improving productivity, reducing environmental impact and enhancing safety. During operation and maintenance, tuning of the drive maximizes its energy savings.

Replacement and recycling
When the drive and motor life cycle is complete, the company can advise that it is disposed of in a way that meets all local environmental regulations, recycling whenever equipment is replaced at end-user sites is encouraged. ABB can advise on the appropriate replacement drive and motor for an application. Depending on the country, the company aims to remove and dispose of any drive and associated equipment in line with the environmental regulations enforced within that country.

Motor management policy
The importance of energy efficiency to a motor's life cycle costs is often not well understood. The energy costs over the life of a motor far exceed the purchase price. A fully loaded motor will typically consume the same in electricity costs within its first three months of operation as its purchase price. However, when swift action is needed, the efficiency of the new motor is rarely considered. The natural instinct of many plant managers is to send a failed motor out to be rewound. But blindly following this habit can cost the company dearly in higher energy costs, as rewinding impairs a motor's efficiency. The solution is to adopt a motor management policy that gives clear guidelines on when to purchase high efficiency motors. In effect, the decision on whether to rewind or replace is taken long before the motor fails. The time spent creating a motor management policy will be paid for many times over by reduced energy costs, less downtime and lower stock inventories.

Case studies
Steelworks [3]
A large steelworks in northern Italy wanted to increase its competitiveness through a significant reduction in the amount of energy being used, which accounted for up to 30% of its manufacturing costs (see Fig. 9). Before the efficiency goals were defined, technicians worked together to analyse the installation itself. After considering return on investment (ROI) periods, a series of drives were installed in the most critical points, especially on the combustion air fans on the furnaces, which previously had been regulated using choke dampers. The installed motor base was also renewed, with an initial batch of 100 high efficiency low voltage motors replacing the same number of standard efficiency motors. Adding together the applications that have been installed, and those that are planned for the future, by its completion the project expects to cut the energy being used by 3000 MWh per year, which could save up to $560 000 every year on its energy bill (Table 1).

A leading paper manufacturer with an overall energy need of 20 TWh a year decided to launch a comprehensive and company-wide energy management system. It involves two central server systems and 19 client systems handling as many as 600 users at a time via 50 different data collection interfaces. The result is the optimised use of more than 100 energy sources (fossil, nuclear, water sources, etc.) The system comes with a direct link to government institutions, trade partners, energy suppliers and energy markets. It took less than a few months for its investment in the new system to pay off when that paper manufacturer cut its energy procurement costs by 35%.

Coal-fired power plant [5]
AGerman coal-fired power plant replaced the hydraulic couplings regulating two boiler feed-water pumps of 5,8 MW each with ABB AC drives. Energy consumption was reduced by about 30% (Table 2).

Conclusion
Drives adjust the speed of electric motors to match the actual demand of the application thereby reducing motor energy consumption by typically 20 – 50%. Drives can facilitate the largest energy saving potential in industry. Today ABB is at the forefront of efforts to reduce global energy consumption and carbon dioxide emissions by supplying safe, reliable and efficient motors. The energy efficiency Appraisal program is designed to identify and put into practice any feasible way in which a production processes can save energy.

Acknowledgement
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References
[1] ABB, (drives and motors for improving energy efficiency), 15125, ABB drives and motors energy efficiency, EN Rev A 23.9 lowres, pp. 2 – 12.

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