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Knowledge Brief

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Electric Motor Asset Management for Energy Efficiency

by Ian Wilson

Introduction

Typically, motors consume 60% of an industrial site's electrical energy. For a secondary pharmaceutical plant, with its heavy reliance on HVAC, it can be more. In primary manufacturing, process loads predominate and motors may constitute more than 90% of site electrical consumption. Therefore, a site's motor asset base must be a major focus of attention in any program to reduce energy consumption and CO_2 emissions.

A motor forms a fundamental part of a system for converting electrical energy to useful work. For example, a mechanical fan, driven by an electric motor, transfers energy into pressurizing and moving air. So, the motor rated efficiency is a key concern and rightly has attracted attention from standards and legislation makers. The IEC 60034-30 for motor efficiency standards is being progressively adopted around the world. A comparison with legacy standards is given below.

For system optimization, it is of course important to consider the whole process, including the driven system, as well as the component parts. Specific fan power, for instance, is a measure of how efficiently air movement is produced from the electrical power absorbed. However, this Knowledge Brief will focus mainly on the motor and its control, relating to applications, where relevant.

Although motor efficiency is clearly very important, speed control of motors can provide very significant savings, especially in fan and pump applications.

Motor Efficiency

Clearly, the efficiency of conversion of electrical to mechanical energy in a motor can play a significant role in a drive system's overall efficiency and it is necessary to ensure that an appropriate life cycle cost approach is taken to motor selection.

Motor rated efficiencies are a function of the quality and quantity of materials used in construction, manufacturing

> Consider an 11kW (15HP) motor costing $600 (€500). If it runs at 75% load factor, 4,000 hour/year at an efficiency of 90% and energy costs $8c/kWh, then the energy cost equals the purchase cost after about 8 weeks. Over a 20 year life span, if maintenance costs are $200 (€150)/year, then the energy represents almost 95% of lifetime costs.

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	CEMEP	USA	IEC 60034-30
Super Premium Efficiency			IE4
Premium Efficiency		NEMA Premium	IE3
High Efficiency	Eff1	EPAct	IE2
Standard Efficiency	Eff2		IE1
Below Standard Efficiency	Eff3		

Table A. Motor Efficiency Standard equivalence.

tolerances and design with higher efficiency motors having a cost premium. Clearly, there is a CAPEX/OPEX balance to strike, but it is worth noting that often more than 90% of a motor's life cycle cost is for energy consumed.

Motor efficiencies are generally quoted at full load, but rarely run as such. As load falls, motor efficiencies tend to fall, significantly so at light loads. It is therefore important to ensure that over-rating does not occur with multiple sizing margins built-in through the mechanical and electrical design steps.

Motor Efficiency Standards

IEC 60034-30 2008 introduced a standard for the classification of motor efficiencies and in so doing attempts to unify the various standards used around the world. Many will be familiar with the old CEMEP classifications of Eff1, Eff2, and Eff3. In NEMA governed countries, there was the Energy Policy Act (EPAct) standard or similar and now NEMA Premium.

Table A shows the new standards and the equivalence with the old.

The IEC standard does not mandate the use of any particular efficiency level, but is used by governments to legislate on minimum efficiency performance standards. However, generally legislation only applies to new motor purchases. In some cases, legislation is phased in over many years and there are generous extensions to allow for depletion of existing stocks.

Life Cycle Management

Companies should create a motor policy to improve the efficiency of this significant asset base, which includes an approach to managing the whole life cycle:

- Selecting the appropriate efficiency class and avoid reliance on long lead-in legislation – ensure specifications for motor purchases are updated for the required efficiency class, including those for Original Equipment Manufacturer (OEM) purchased equipment.
- Auditing to understand the existing asset base and benchmark against current high efficiency standards.
- Prioritizing effort on motors with high running times.
- Identifying motor efficiency upgrade opportunities.
- Determining a repair/replace policy (note that motors can lose 1 to 1.5% efficiency for each rewind) and manage spares availability to allow energy efficiency policy to be the deciding factor and not emergency repair for plant uptime.
- Applying an appropriate maintenance strategy.

The choice of motor efficiency standard for new purchases has to be made in relation to local availability and support, legislation, and life cycle costs. In the US, the IE3 equivalent, NEMA Premium is already mandatory. In Europe, the European Minimum Energy Performance Standard (EU MEPS) provide for a phased program from the current IE2 minimum to IE3 over the next few years.

The IE4 efficiency levels were declared in the IEC standard in 2012 and motors meeting this standard are becoming commercially available based on permanent magnet technology with integrated speed control.

Motor Control

With the large volumes of air movement in pharmaceutical manufacturing, the filtration, treatment, and pressurization of this air is a major component of a plant's energy use. Therefore, the management of the air flow to the optimum necessary for meeting compliance and product quality should rightly be of concern when considering energy reduction.

The most effective way to manage air flow rates is control of motor speed using Variable Speed Drives (VSD), which are easy to retrofit. It is important to ensure that VSDs are effectively controlled either directly at the VSD or through the Building Management Systems (BMS), which are straightforward applications enabling retrofits of VSDs to be achieved with minimal disruption. Typically, pressure sensors are used to control flow, enabling automated changes to be made according to requirements – full design flow rate during production and relaxed levels for non-production periods. Pressure sensors fitted across a filter can monitor the gradual clogging of the filter and the BMS can be set to provide a maintenance alert when it becomes economic to change the filter and so reduce the fan power. Consequently, maintenance can be scheduled at the optimum time, balancing energy and filter costs, and not at a fixed interval.

In a similar manner, VSDs can provide significant energy savings in pumped systems by varying flow rates according to system demand instead of a fixed volume. Common applications include chilled and hot water distribution to air handling units and cooling towers.

For further technical information on VSDs and their application, see the *Phar-*

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maceutical Engineering article "Variable Frequency Drives Role in Control System Strategy" by Irina Kurjatko.[1]

Power Quality

Motors require a power supply of the right quality standard to meet rated efficiency and performance levels. Deviations from this standard can not only increase losses, but cause premature failure. Harmonic distortion results from non linear loads on the electrical system, which include many electronic devices including variable speed drives. It will affect motor performance and can cause heating effects in windings. There are further reasons for ensuring harmonic distortion is managed, but this is outside the scope of this Knowledge Brief.

Voltage imbalance at the motor terminals is another cause of losses and can cause vibration and premature motor failure. The US Department of Energy recommends that voltage imbalance is less than 1%. Tests they carried out showed that at 2.5% imbalance, motor efficiency could fall by as much as two percentage points and is in their view the leading power quality problem leading to motor overheating and failure. Periodic testing of voltage at the motor terminals is advisable. Further information is available from their Motor Systems Tip Sheet.[2]

Power quality surveys will reveal any issues of concern and mitigation solutions are readily available.

Conclusion

Motors consume a large proportion of a pharmaceutical facility's electrical energy. Taking a life cycle approach to motor management is essential to optimize the efficiency of this important asset base. Without a good policy, local approaches may overlook important energy efficiency best practice in favor of operational expediency. Motor efficiency is important and speed control can deliver large savings, especially in fan and pump applications. Appropriate quality power supplies to motors are important to ensure efficient and long lasting operation.

References

1. "Variable Frequency Drives Role in Control System Strategy" by Irina Kurjatko, *Pharmaceutical Engineering*, May/June 2007, Volume 27, Number 3.
2. US Department of Energy - Motor Systems Tip Sheet: http://www1.eere.energy.gov/manufacturing/tech_deployment/pdfs/eliminate_voltage_unbalanced_motor_systemts7.pdf

For Further Information

For more detailed information, the following ISPE resource is available:

HVAC and Sustainable Facilities Communities of Practice (COPs):

- Visit the HVAC COP and Sustainable Facilities COP for the most current and up-to-the-minute discussions on the topics discussed in this Knowledge Brief and other related topics.
  http://www.ispe.org/disposablescop
  http://www.ispe.org/sustainablefacilitiescop

About the Author

Ian Wilson is the Global Energy Programme Manager, working in Schneider Electric's Life Sciences Team, supporting global pharmaceutical companies in energy efficiency and electrical power solutions. This role has entailed the development and deployment of global energy management programs across electrical systems, motors, HVAC, and BMS. He has more than 30 years of engineering experience, 20 of which have been with Schneider Electric, enjoying a varied experience in project management, technical consultancy and operations management. Wilson is a Chartered Electrical Engineer and holds corporate membership of both the IET and IMechE. He has a BSc in engineering from the University of Bath and an MBA from City University in London. He is based in the UK in the North of England.

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