Copper & High Efficiency Motors

Electric motors are available with a wide range of characteristics and power outputs, making them the ideal drives for a very broad range of applications.

Most motors operate at less than their design capacity. It is important that high-efficiency motors retain their energy efficiency at these loads. The justification for the initial premium is simple: an electric motor can consume electricity to the equivalent of its capital cost within the first 500 hours of operation-a mere three weeks of continuous use.

The lifetime cost of losses is several times the purchase price of the motor. Clearly, the lowest overall cost will not be achieved unless both capital and running costs are considered together.

A well-designed motor can convert over 90% of its input energy into useful power in its life-time. When the efficiency of a motor is raised by even a few percentage points, the savings, in kilowatt hours and therefore in cost, are enormous.

For example, it has been estimated that if all countries adopted best efficiency standards for industrial electric motors, by 2030 approximately 322 TWh of annual electricity demand would be saved. As an additional environmental benefit, this savings corresponds to a saving of 206 million tons of CO_2 emissions.

Energy losses of electric motors fall into various categories:

- Electrical losses (Joule losses): due to electrical resistance of the windings, conductor bars, and end rings
- Magnetic losses: due to hysteresis and eddy currents of the magnetic field in the steel laminations
- Stray load losses: due to imperfections in the flux (leakage, harmonics, irregularities, etc.)
- Mechanical losses: due to friction

Moreover, the percentage of energy losses increases when the motor's load is further away from its nominal value.

Manufacturers, with various manufacturing associations and voluntary government initiatives, have developed a wide range of motors with increased electrical efficiencies.

Governmental and inter-governmental agencies, seeking to achieve energy savings and reduce carbon footprints from efficient industrial motor systems, have issued increasingly stringent standards and regulations requiring users to buy high- and premium-efficiency motors instead of standard efficiency options for many applications.

Initiatives exist for nations to move towards Minimum Energy Performance Standards (MEPS). In 2002, five nations adopted MEPSs. By 2011, 39 nations adopted some form of mandatory MEPS for three-phase electric motors. Motors in these countries account for 70% of global electricity use in motor systems. If the mandatory MEPSs in these 39 countries were raised to best-practice levels, savings could approach 206 million tonnes of CO_2 emissions annually by 2030.

Copper saves more money in the long run

High efficiency motors pile up savings worth many times their purchase cost for as long as they remain in service.

There is a capital investment that can repay many times its original value over the next 20 years. And at the same time, improve equipment reliability, reduce downtime and repair costs, and result in lower releases of carbon dioxide to the atmosphere.

The formula is straightforward: install high efficiency motors having the highest electrical energy efficiency commensurate with your needs.

Understanding High Efficiency Motors

Electric motors are simply devices that convert electrical energy into mechanical energy. Like all electromechanical equipment, motors consume some "extra" energy in order to make the conversion. Efficiency is a measure of how much total energy a motor uses in relation to the rated power delivered to the shaft.

A motor's nameplate rating is based on output horsepower, which is fixed for continuous operation at full load. The amount of input power needed to produce rated horsepower will vary from motor to motor, with high-efficiency motors (HEM) requiring less input wattage than less-efficient models to produce the same output. Electrical energy input is measured in watts, while output is given in horsepower. (This convention applies in the USA; output power for motors manufactured in other countries may be stated in watts or kilowatts.) One horsepower is equivalent to 746 watts.

There are several ways to express motor efficiency, but the basic concept and the numerical results are the same. For example: The ratio describes efficiency in terms of what can be observed from outside the motor, but it does not say anything inside that makes one motor more or less efficient than another. For example, we can rewrite the equation as:

$$\text{Efficiency, \%} = \frac{746 \times \text{Horsepower (output)} \times 100}{\text{Watts (input)}}$$

$$\text{Efficiency, \%} = \frac{\text{Watts (output)} \times 100}{\text{Watts (input)}}$$

or its equivalent,

$$\text{Efficiency, \%} = \frac{\text{Watts (output)} \times 100}{\text{Watts (output)} + \text{Watts (Losses)}}$$

$$\text{Efficiency, \%} = \frac{\text{Watts (Input)} - \text{Watts (Losses)} \times 100}{\text{Watts (Input)}}$$

"Losses" stands for all the energy "fees" the motor charges in order to make its electrical-to-mechanical energy conversion. Their magnitude varies from motor to motor and can even vary among motors of the same make, type and size. In general, standard motors have higher losses than HEMs.

High Electrical Conductivity

Conductivity is an important characteristic of the rotor. Conductor bars in large motors are normally made from high-conductivity copper. Conductor bars in small-to-intermediate size motors, up to about 200 hp, depending on manufacturer, are in the form of a die-cast aluminum "squirrel cage" that gives these motors their common name.

Increasing the mass of the die-cast bars requires changes in the slots in the rotor laminations, through which the bars are cast, and that changes the rotor's magnetic structure. Lowering rotor I^2R losses in what are typically aluminum alloy squirrel cage motors is therefore not a simple task.

Copper has higher electrical conductivity than aluminum, and it would be an ideal conductor bar material except for the fact that it is difficult to die cast. A process to produce die-cast copper rotors has recently been developed and, when fully commercialized, it will enable the production of motors with even higher efficiencies than the best models currently available.

The fact that HEMs tend to have less slip (run faster) than standard motors must be taken into account in certain applications.

For example, energy consumption by centrifugal loads such as fans and rotary compressors is proportional to the cube of rotational speed. If such loads are driven at the higher speed of a low-slip, HEM directly replacing a standard motor, energy consumption can actually increase. This situation may be resolved by lowering rotational speed with a variable-speed drive, gears or pulleys. There are other parameters, such as torque or starting current, that can vary among motors of the same nominal horsepower. It is important to properly engineer the application of any motor to the intended task.

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