EC Motors
REVVING UP
Big HVACR Advantages

Energy efficiency, low noise, variable speed, reliability and advanced communication capabilities help make them "future-proof."

BY LOU MOFFA

Images courtesy of ebm-papst Inc.

An EC motor with optimized blade, grill and venturi design.

Ongoing government regulations and energy incentives are forcing commercial refrigeration manufacturers to create new products or redesign existing ones that will meet more demanding energy and environmental restrictions.

Older products that do not comply are being redesigned to meet these new standards and also work with new refrigerants. Natural refrigerants, such as ammonia, CO_2 and hydrocarbons are being chosen as "future-proof" selections that will not be part of any upcoming agency phase-out. During these design changes, it is a perfect time to consider new choices that are available for the energy consuming components, such as fans and compressors.

Considerations when upgrading systems

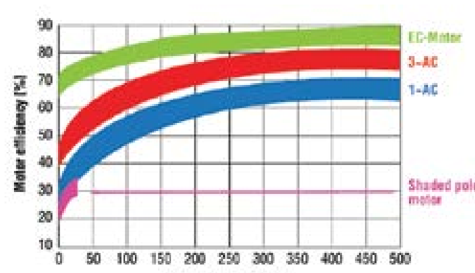
Fans are a critical component of any refrigeration system, with one or more found at the evaporator and the condenser. The commercial refrigeration market is comprised of supermarket display cases, rooftop condensers, standalone bottle coolers, merchandisers, commercial kitchen refrigerators and freezers, and large evaporative cooling systems. All of these product lines can benefit from the latest Electronically Commutated (EC) fan technology which provide advantages such as reduced energy consumption, variable speed operation, low operating noise, increased reliability, and advanced communication capabilities.

Upgrading to EC motor technology

One of the biggest energy consumers of any refrigeration product has been the electric motor used on the fans. Converting electrical energy to mechanical energy is not always very efficient. The most common type of AC motor, the induction motor, has been around for over 100 years and is still the workhorse of many industries. They come in a variety of sizes and power levels and are widely available. However their efficiency is limited due to their design. The alternative, EC motors, are now becoming the motor of choice and are proving to be a major source of energy savings. EC motors are now available in more and more sizes and power outputs. When EC motors are used to drive a fan, they not only provide energy savings, but a reduction in overall size, weight and noise. At first glance they may seem complicated, but these motors offer many advantages that make products better through added features, greater reliability and higher performance.

So what are the differences in design between an AC induction motor and an EC motor? AC induction motors come in various sizes and designs, and are used in all industries: HVAC, refrigeration, appliances, etc. Their operation is fairly simple. The AC power supplied to the stator creates a magnetic field. This field rotates with the frequency of the supply voltage, inducing an opposing current in the rotor.

The rotor will then turn to oppose the direction of the rotating magnetic field. This may be an external rotor connected to fan blades, or turn a shaft to do the needed work. The speed of such a motor cannot be higher than the synchronous speed, which is dependent on the frequency of the input voltage and the number of poles in the motor.



The typical efficiencies of various AC induction motors versus EC motors are shown in this chart.

There are different types of AC induction motors available. The most common are: 1) shaded pole—smaller fractional horsepower, with low torque; 2) capacitor run and capacitor start motors—both requiring an additional capacitor to operate; 3) three-phase motors—which run on three-phase supply voltage.

The key difference between AC induction motors and EC motors is that EC motors run on standard 1-phase or 3-phase AC power but internally are brushless DC motors with built-in electronics that convert the incoming AC power to DC. This enables them to be used in common AC applications. The rotor contains permanent magnets and the stator has a set of fixed windings. A circuit board continually switches the phases in the fixed windings to keep the motor turning. Because the speed of the motor is controlled by the commu-tation electronics, these motors are not limited to synchro-nous speeds. DC motors and EC motors have typically been reserved for smaller power output applications, filling such applications as small fans, pumps, servomotors and motion control systems. However, advances in electronics and materials are allowing larger output motors of 12kW (16hp) or even higher. These motors are now finding homes in everything from small appliances to conveyor belts and large rooftop condenser units.

As mentioned, efficiency is the most common reason for choosing an EC motor over an AC motor. With an EC motor, the commutation is accomplished by the electronics reducing the losses internal to the motor. The chart on page 14 shows the efficiency of each motor type. Perhaps the biggest energy savings comes from the ability to speed control EC motors. While AC motors are available with multiple speeds or can be controlled with external devices, these add complexity and have limitations.

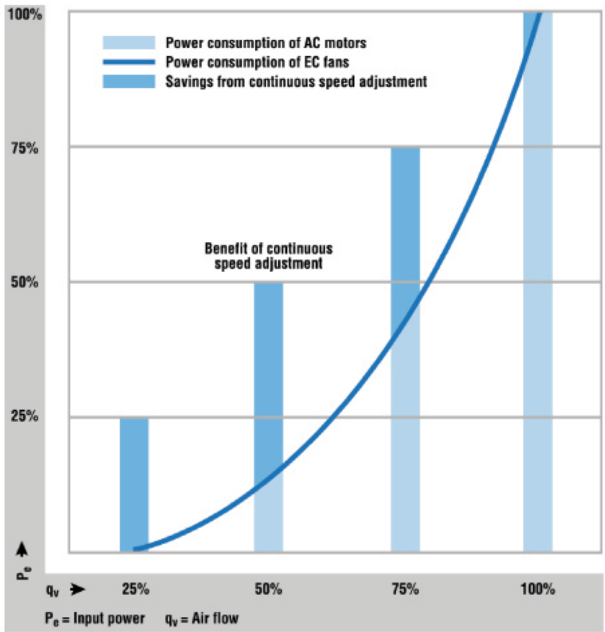
Two-speed AC motors can be noisy, or not optimized for the system. Three-phase motors can be controlled with VFDs, but a complicated system of filtering and protection is needed to properly protect the motor from damage. The chart on page 16 shows the energy saved by speed adjusting a multiple EC fan system vs cycling AC induction fans on/off as needed.

Compact size

Since efficiency is improved, a smaller motor size may be used to achieve the same power output. A smaller motor also equals lower weight and allows for smaller end refrigeration systems products or more room for additional features. Many EC fan manufacturers also offer external rotor designs rather than shafted motors, and their compact design allows for even more space savings. Smaller fan sizes, especially in an under counter refrigerator, allow for more interior storage room without sacrificing performance.

Input voltage

EC motors are not completely dependent on voltage and frequency. Small changes in voltage do not have an effect on motor output, and 50-60 Hz can be used without a performance difference. This means that when the motor is powered within the stated operating voltage range with either 50 or 60Hz frequency the motor will always perform the same. This is important for products that are required to have the same output performance when used in various countries.



This chart shows the power saved with speed controlling a system of EC fans versus cycling AC fans.

with different main power outputs. Usually the end product may have to be de-rated when used in other countries. EC motors eliminate this problem. More and more EC motors are also available with wide voltage range input so the same motor can be used with 115 or 230VAC with no adjustments at the motor needed, further reducing motor variations.

Easy speed control

AC motors are available with multiple speeds and with optional external speed controllers. Multiple speed fans are usually offered at a premium and do not always operate at optimum efficiency at reduced speeds.

External speed controls typically adjust the incoming voltage by altering the smooth AC sine wave. This is not always good for motor lifetime and could increase noise. This is especially true with three-phase motors using a variable frequency drive (VFD). A complicated system of filters and grounding is needed to protect the motor, in addition to properly matching the VFD to the motor and the complexity of programming the VFD to achieve the performance needed. All this can be avoided with the use of an EC motor.

Most EC motors will come with multiple-speed control inputs, not as an option, but standard. The commutation circuit can easily accept inputs such as PWM, 4-20mA, and 0-10V linear, to control the speed typically in the range of 10%-100%. The control side of the motor is a low-voltage circuit separate from main power. This circuit can even provide voltage to power external sensors, eliminating the need for separate DC power supply for these sensors.

Individual motors can be programmed to perform process control with adjustable PI functionality. This could allow a system designer the flexibility to eliminate a main controller or to use the fan's process controller as a back-up to the main controller again, simplifying the overall design and adding redundancy.

EC motors can be programmed at the manufactur-ing site or in the field, allowing the end user to run at specific rpm settings that are determined by the manufacturer to provide the correct airflow. Having one EC motor, with the ability to pro-gram it to be used in various end applications, helps reduce inven-tory variations at the manufacturer as well as on the repair truck.

Protection

Included in most EC motor electronics is protection against voltage overload, low-voltage conditions, phase loss, power surges, locked rotor and overheating. All of these issues are root causes of AC induction motor failure.

The three-phase AC input is converted to DC voltage in the motor, eliminating the need for the correct phase wiring. The motor will run in the correct rotation as per the software settings, not the phase orientation. On larger three-phase input EC motors, guessing which wire is L1, L2 or L3 is no longer required; it doesn't matter. In AC motors, many of these protective features are only available by purchasing external components, adding cost and complexity.

> "EC motors easily adapt to Internet of Things (IoT) designs, allowing for remote accessibility to the health of each EC motor."

Motor feedback

With current AC motor technology, even simple feedback, such as monitoring the motor rpm, would require a mix of sensors and external DC circuits. The existing internal monitoring functions of an EC motor can be easily accessed by the HVACR appliance manufacturer to provide end user feedback about the motor. Using BUS communication, parameters such as error codes, motor life, and motor temperature are available. Using the motor status relay available on many larger EC motors, a motor error can trigger a wired alarm or send an alert message. DC tachometer outputs are commonly available on most EC motors, and all of these allow the HVACR appliance manufacturer to integrate features that make their product easier to troubleshoot and monitor by the end user.

EC motors easily adapt to Internet of Things (IoT) designs, allowing remote accessibility to the health of each EC motor. Having access to this information can help end users and repair technicians know the exact status of individual EC motors in a system and make preventive mainte-nance on the entire refrigeration system much easier, without the need for add-on monitoring devices.

Additional advantages

→Soft start—the software and electronics of an EC motor are usually set for a soft start when power is applied, reducing startup current and preventing nuisance breaker trips.

→Noise—with speed controlled AC motors, noise levels will show spikes corresponding with the voltage frequency (motor hum), but not so with EC motors.

→Heat—increased efficiency of an EC motor results in a cooler running motor and lower thermal load on the HVACR system. Also, lower motor temperature equals lower bearing temperature equals better reliability.

Additional features

Additional features are incorporated in certain EC motors, depending on the size and end use.

→BUS communication—EC motors are perfect for integration into system control and monitoring or into existing building management systems.

→Modbus, is available on many motors. Now each motor can be referenced through the controller or the building's management system, and the status of individual fans can be viewed and the output adjusted as needed, to specific individual fans or to groups of fans. BUS communication offers two-way communications between the controller and the motor, with information rich feedback.

→Complicated control scenarios—this includes commands like reverse rotation on startup to loosen a blocked rotor, or a soft start override to loosen a frozen fan blade. The EC motor electronics can also be programmed to go to a default setting if there is a BUS communication interruption.

→Multiple motor operations—in systems such as rooftop condensers, it is possible to program one fan as the master processor and have it control the remaining fans to all perform the same based on a target set point. The process control logic can reside in the motor, eliminating the need for a separate controller or use of a backup to the main controller.

EC motors are quickly becoming the standard in many refrigeration and HVAC fan and motor applications - not just for the obvious energy saving reasons, but because of the additional features that come with this versatile technology.

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