Understanding ECMs and Replacement Options

A general overview of the types of electronically commutated motors and replacement options that are available for technicians in the field.

BY GREGG YOUNG

Images courtesy of Nidec Motor Corp.

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In January 2006, the U.S. Department of Energy (DOE) changed the minimum efficiency in the United States from 10 to 13 SEER. There were several system changes that contributed to this efficiency increase. Some were obvious, like a larger coil on the condensing unit. Others were less apparent, such as: using a more efficient compressor; adding a thermostatic expansion valve; upgrading the motor from a permanent split capacitor (PSC) to a high-efficiency, electronically controlled motor (ECM); or some combination of these three technologies.

Upgraded ECMs, sometimes called brushless permanent magnet (BPM) motors, contain magnets attached to the rotor and an electronics package to control the torque. This allows the OEM to vary the motor's speed based on system inputs. By doing so, motor efficiency is increased by more than 20% over the previous generation's PSC designs. By controlling the motor behavior via electronics, OEMs improved HVAC comfort levels and used the improvement to justify the increased cost to the consumer of added controls and system complexity.

A cross between an ac induction motor and a conventional dc motor, BPMs are synchronous motors that, like dc motors, use permanent magnets and electrical windings to create rotation. Their stator structure, on the other hand, resembles that of their ac induction motor cousins, whose windings are constructed in a way that produces a sinusoidal flux density in the air gap of the machine.

With higher DOE 2015 standards being implemented in the southern part of the United States and elsewhere, sales of units containing ECMs will continue to grow. It is increasingly important, for the sake of maintaining system efficiency, to understand motor replacement options.

Types of ECMs/replacements

There are three main types of ECMs: constant torque, constant cfm (or speed) and a communicating version of the constant cfm (or speed). Each of these has different cost positions, features and benefits that can be found in different SEER groups of equipment.

What is the end result? Compared to ac induction motors, ECMs provide higher power density for their size. They have longer life spans and require less maintenance, too. That is because part of the stator current on an induction machine is used to "induce" the rotor current to produce rotor flux. These additional currents generate heat within the motor and lower its efficiency. With the brushless design of an ECM, the rotor flux is already established by the permanent magnets on the rotor. BPM motors also provide substantial torque over a range of speeds, and display similar torque and speed performance as brushed motors.[1]

The problem facing the contractor is that when a motor fails and the furnace or air-handler cannot function, there are limited choices for making a quality repair of the unit,

while also maintaining the system's efficiency. First, the technician must identify the type of motor and then choose a replacement option. In the two types of constant speed or cfm, a replacement must come from an OEM parts outlet or a wholesaler authorized to sell the OEM's parts. While motors can last many years, many of them are getting up in age and OEM replacement parts outlets are starting to stock some replacement motors and/or controls depending upon the equipment manufacturer's strategy.

> **Increasingly and with short lead times, there are programmable OEM replacement motors available to meet the needs of both the technician and end user.**

Option 1: manufacturer direct

One area that has more choices for the independent technician is in the constant-torque type of ECM. These are typically identified by the manufacturer's product family name on the motor nameplate. Replacements for these motors are available through the OEM channel and independent distribution.

The alternatives offer various benefits, but what we will look at here are the attributes as seen by the homeowner and the widely varying results and comfort levels that will be created. The OEM direct replacement that was first offered provides the homeowner with a motor programmed with the same parameters as originally used to preserve the efficiency of the unit. The technician then can plug the wiring from the control board into the new motor's terminals in the same position as the one that was removed. There are nine slots in the terminal on the motor. If the OEM used a multi-tap plug, then the challenge is reduced. But if not, there are nine spade terminals to negotiate. The lower five (furthest from the shaft) are the 24-V speed taps and the upper set, are the line voltage to power the motor and ground. The system engages the 24-V tap to tell the motor which program setting to follow. The technician can only mimic the original hookup, as there is no way to tell what the 24-V settings are for that particular motor. These specific values are programmed to create a pre-determined amount of torque for the motor to apply when that speed tap is energized. If the technician cannot mimic the original install, the equipment will not run as designed, degrading efficiency and performance. Fortunately, with the increasing size of the aftermarket for these motors, other non-OEM supplied product has broadened the technician's replacement options.

The side view of an ECM rotor.

Option 2: OEM replacement motors

Increasingly and with short lead times, there are programmable OEM replacement motors available to meet the needs of both the technician and end user. Using the same method the OEM's use to program these motors on their production lines, OEM replacements are now available to the independent wholesaler.

The front view of an ECM rotor.

> **By not matching the original motor's air flow, the unit may not dehumidify as well due to excess air flow in cooling.**

A technician can pick a motor from stock that is not programmed already, have the wholesaler enter the part number into a computer and the computer will feed the torque settings into the motor at the counter via an intranet connection. This product offering gives the end user a quick repair that maintains system efficiency, gives the technician an easy-to-install replacement that matches up with the OEM specifications and, provides better turns for the wholesaler concerned about inventory levels. Make sure to always double check those temperature deltas in cooling and heating.

OEM replacements are available from those offering programmable units to their independent distributors.

Option 3: generically programmed motors

The third group of replacement products on the scene is generically programmed motors. While these can be used to try and replace any constant-torque motor, they do create challenges for the technician, such as the time it takes to approximate the original motor's air flow and the resulting efficiency of the unit.

An example of a programmable replacement motor for a variety of HVAC equipment.

Since these generic units are programmed in one slope high to low, the tech must try each speed tap and each mode of the unit to figure out which tap best approximates the OEM's cfm specifications. This takes extra time to figure out and lengthens the service call. More importantly, the technician who only does a quick repair and does not follow this procedure may be setting up for a callback.

By not matching the original motor's air flow, the unit may not dehumidify as well due to excess air flow in cooling. That in turn, may create opportunities for mold. The result might be an end user who turns the temperature down for relief, running the system longer and causing a higher electric bill. In the heating season with two-stage units becoming more common, correct air flow is important in both stages for the unit to operate efficiently and properly, avoiding overheating or noise issues.

Programmable products offer a distinct advantage to both contractors and end users. The technician saves time, gains access to equipment brand replacements at independent wholesalers, and, most importantly, can complete a faster installation with a motor that approximates the original efficiency without the trial and error required when using generic replacements.

References
[1]*"High Efficiency Motor Technology" by Scott Durfee, Appliance Design, April 2015.*

Gregg Young is Manager of Marketing Services at Nidec Motor Corp. He has been in the HVACR industry for more than 25 years in a variety of technical and marketing roles. For more information, email gregg.young@nidec-motor.com or visit www.usmotors.com.