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"INVERTING"

How Split Systems Push the Efficiency Envelope

BY ALLAN REIFEL AND DAVE KOESTERER

Inverter-driven rotary technology–initially seen in mini-splits and window A/C units–is finding its way into ducted-system use, as shown here on this air-conditioner install in Louisiana.

Efficiency levels as high as 24.5 SEER have been achieved by inverter-rotary split system air-conditioning units, making them an attractive option for homeowners.

Long found in mini-split systems and window units, inverter-driven rotary technology is now finding a home in traditional duct systems too.

Imagine living in a major metropolitan city where, for the vast majority of the populace, small apartments are the only affordable option; temperatures consistently reach 90°F in the summer with 85% humidity levels; and the A/C unit literally hangs outside the apartment's only window, scant feet from a neighbor's single window.

These living conditions—found in Asian cities from Beijing to Istanbul, and all points between—are the reason inverter-driven rotary technology for air conditioners was developed. Twelve years ago, Asian governments saw the need to reduce noise pollution and energy demands, and their demands drove manufacturers to create outdoor units that would perform quietly and efficiently.

Today, more than 80% of compressors worldwide use rotary technology. In the United States, this technology was first seen in mini-splits and window units; and in 2006, the U.S. marketplace saw the first application of inverter-rotary technology in a traditional ducted system. This type of split-system air conditioner has achieved efficiency levels as high as 24.5-SEER—a rating significantly higher than even the most stringent regulations.

Knowing the basics

Understanding why these units are so efficient requires that the technician understand what they contain. There are three key components when it comes to inverter-driven rotary technology.

The inverter—This element changes electrical current from ac to dc and is highly versatile when controlled by

programmed logic. In this case, the inverter varies the input frequency to the high-efficiency compressor and fan motors to control speed, and varies the voltage to control torque.

The rotary compressor—Every compressor used in residential cooling has two main functions: to pump refrigerant through the system; and to boost pressure and temperature of the gaseous refrigerant, which allows the high-temperature gas to release the heat absorbed from the indoor air to the outside air.

In a rotary compressor, the refrigerant is compressed by the rotating action of a roller inside a cylinder. The roller rotates off-center around a shaft so that part of the roller is always in contact with the inside wall of the cylinder, while a spring-mounted blade consistently rubs against the roller. Both of these contact points create two sealed areas of continuously variable volume inside the cylinder.

During the roller's rotation, the intake port is exposed and refrigerant is sucked into the cylinder, filling one of the sealed areas. As the roller continues rotating, the refrigerant is compressed and forced to exit when the exhaust valve is exposed. Rotary compressors are very efficient because they take in and compress refrigerant concurrently.

Electronic expansion valve—The EXV is used to adjust refrigerant flow to match the cooling load. Formerly used only on commercial equipment, the EXV is analogous to an electronic fuel-injection system on a car, whereas the standard TXV is similar to a carburetor. [*Editor's Note: Nordyne, the only North American manufacturer currently involved in the production of inverter-driven rotary technology, features an EXV on its inverter-rotary system for North American residential applications.*]

What makes it new(s)?

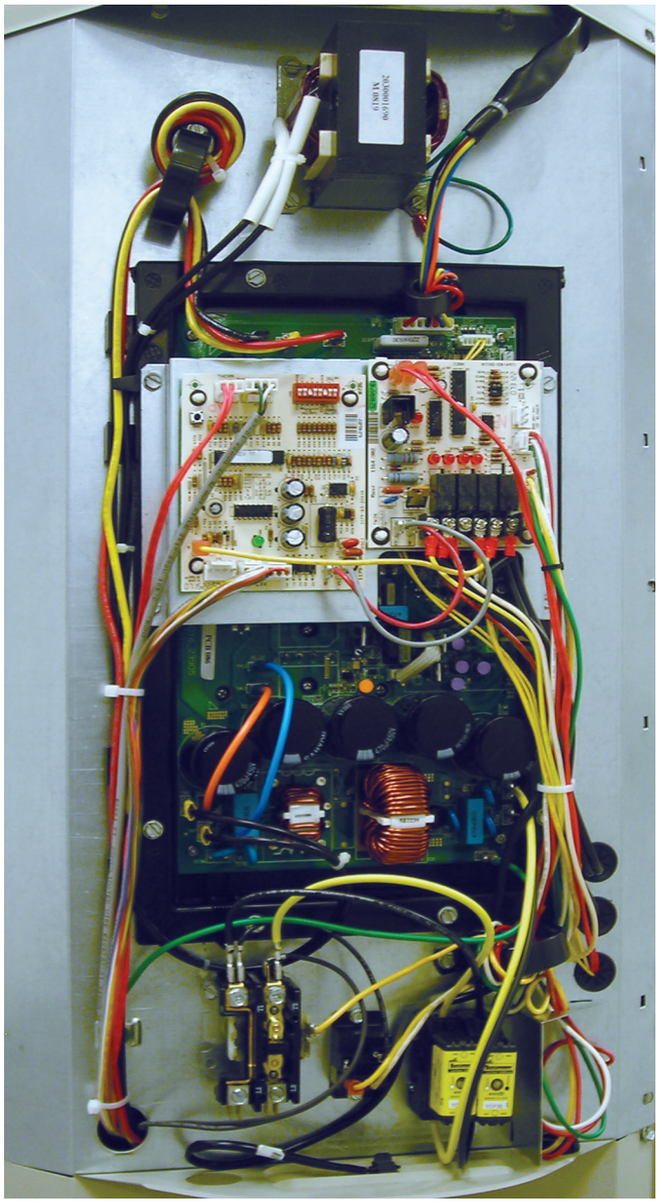
Neither inverter technology nor rotary compressors are new, so why is an inverter-driven rotary system such news? Well, because of the way it all comes together, which happens with the system's drive controller.

The technician installs a controller inside the home that "talks" to both the outdoor unit and the equipment. It assesses the space's cooling load, and uses this information to compute and then communicate the ideal speeds to the inverter and to the indoor fan. The inverter then adjusts its output voltage and wave form to achieve the desired compressor and fan speeds.

In addition to the controller talking to the compressor through the inverter, the inverter and controller continuously get feedback from the compressor in case further adjustments are necessary. This communication occurs several times per second, providing near-constant interaction.

If paired with an air handler, the controller also will periodically calibrate the indoor blower by performing a load calculation on the duct system and measuring air flow resistance—enabling the system to "learn" the duct characteristics of the home so it can perform at optimum efficiency. When matched with a high-efficiency furnace, the controller communicates directly with the blower and indirectly with the furnace controls to achieve the same flexible result.

In addition to controlling the outdoor unit, the controller has diagnostic capabilities that alert the homeowner when a service call is needed and provide the service technician with information to help quickly assess the problem.



While the control board of the heat-pump version of an inverter-rotary system can seem intimidating at first, basic factory training can help technicians and contractors understand all the in-and-outs of the controller.

Inverter-driven rotary A/C units also are notable because they essentially run continuously to satisfy the cooling load. Because motors can modulatet the system's speed, the air conditioner rarely shuts off like a traditional system; it is always running and fine-tuning its speed—anywhere from 403–118% of capacity.

A/C units are very inefficient during start-up, and the more a unit cycles on and off, the more energy it wastes. By eliminating the conventional on-and-off cycling, an inverter-driven rotary unit saves an amazing amount of energy; its long cycle-run time enables it to achieve up to 24.5-SEER in straight cooling applications—saving an average of 2,000 kWh/home annually compared to a 13-SEER system.

Additionally, the unit's drive eliminates the noise associated with cycling on and off. And because the motors are running the majority of the time at a reduced capacity and lower frequencies, the entire unit is extremely quiet.

Understanding installation

Like any HVAC system, success is directly tied to the quality of the installation. Installed properly, an inverter-driven rotary system will provide trouble-free operation for a long period of time. However, if the system is wired incorrectly during installation, sensitive electronic components can be damaged.

Some contractors are naturally intimidated by the critical role that wiring, multiple circuit boards and software play in inverter-rotary split systems. That is why training—learning what the controller can do and how it operates—is so important. Once the contractor understands the controller, the system is actually quite easy to install.

"You would think with everything that this system can do and monitor that it would be difficult to install, but the truth is that it is as easy, or easier, to install than other systems," says Kenny Carter, Owner of Comfort Control Heating & Air LLC in Denham Springs, LA.

Carter—a 21-year vet working as a heating and cooling contractor—has had success selling and installing inverter-rotary systems, and notes that the system installation is very similar to standard 13-SEER systems. For example, he says that only four control wires linking the indoor unit to the drive controller; and five wires from the indoor to outdoor unit are necessary.

"Where standard two-stage-heat, two-stage-cool split systems [are being installed], you may need as many as 8–10 control wires," adds Carter. "This makes it much easier [for] the technician to wire the system."

After the installation is complete, technicians service the system as they would a typical split-system air conditioner or heat pump; because of the advanced diagnostics on the controller, servicing these systems may actually be easier. Dealers can program their names and phone numbers into the controller to be displayed when servicing is needed. The system uses R-410A refrigerant and requires standard periodic maintenance.

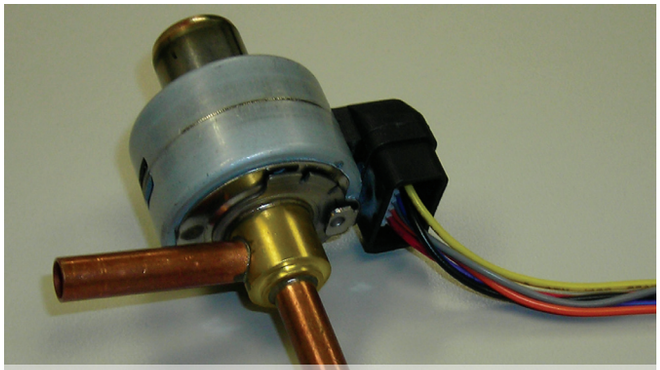
Selling to homeowners

The allure of a 24.5-SEER rating is reason enough for homeowners to be interested in this technology. Based on average cooling hours and utility rates, a homeowner may save $355/year by upgrading from a 10-SEER to a 24.5-SEER, 3-ton unit. For homeowners worried about their carbon footprint, techs can explain that making this type of change is the environmental equivalent of taking one of their cars off the road for nearly five months each year. But many will tell you that energy efficiency is not the sole reason for choosing a system like this.

According to Carter, along with the obvious efficiency benefits, two other things usually close the deal with homeowners: "The system is extremely quiet—both the indoor and outdoor units. Plus, there are no temperature swings since the system has the capability to run at extremely low and high levels."

In addition to the low sound levels and even temperatures, the inverter-rotary technology also delivers whole-home comfort through its built-in dehumidification features.

The system is designed to achieve comfort by first controlling the air temperature, then analyzing humidity levels and use the variable-speed blower to remove moisture from the air. While many systems remove moisture from the evaporator coil by slowing down the blower, the inverter-rotary drive additionally monitors evaporator temperature so that the coil will not freeze. After dehumidifying the home for a calculated time, the blower periodically speeds up again so that air remains uniformly distributed and well-mixed.



Inverter-driven rotary split systems also are unique in that they employ the residential application of an electronic expansion valve to help control the system.

What is next

As energy costs continue to rise, more homeowners are considering—and purchasing—this technology. With the heat-pump companion available as a straight heat-pump/air-handler system, or in a dual-fuel application paired with a gas

furnace, market demand and penetration of this technology should increase.

"[Nordyne's] iQ Drive sales are growing," says Carter. "I think that this is linked to the fact people are becoming more aware of what is available as far as super-high efficiency systems."

Expansion of this technology is expected in the form of accessories, specifically for zoning; contactors can expect to see zoning capabilities in 2010 barring any unforeseen roadblocks.

"This system is so nice to have in our business," adds Carter. "I can't tell you how many jobs we've been awarded when the customer was initially dead-set on a two-stage variable-speed system. We introduce them to [this type of] system, and they fall in love."

From technology developed out of Asian necessity to a North American high-end luxury, inverter-driven rotary air conditioners serve to remind us that the heating and cooling industry is always evolving, and always improving.

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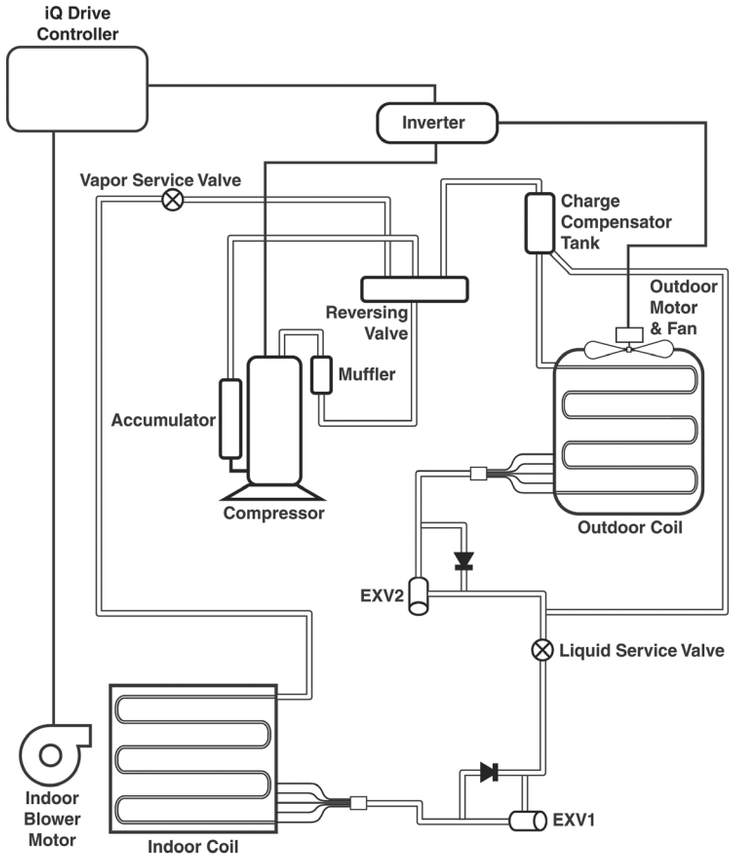

This block diagram shows how all the components of an inverter-rotary heat pump come together in cooling mode.