INVENTIONS & INNOVATION

Project Fact Sheet

High-Speed Permanent Magnet Motor Development for Advanced Cooling Technology

Benefits

- 10 to 15 percent annual energy savings due to higher motor and electronics efficiency—a 28-horsepower motor driving a 25-ton centrifugal compressor would save approximately 9000 kWh per year
- 15 percent more efficient centrifugal compressor compared to current AC systems
- At 100 pounds, the lighter, smaller, and quieter drive offers significant installation savings compared to conventional AC package units with 500 pound compressors
- Variable speed capability keeps efficiency high while matching changes in demand

Applications

SatCon designed a high-speed permanent magnet motor and electronics to drive a new centrifugal compressor developed by an industry technology consortium. The drive is suitable for 25-ton and larger rooftop air conditioning units.

A new application of permanent magnet technology promises lower operating costs and less environmental impact

Alternating current (AC) induction motors, also known as “squirrel cage” motors, drive compressor systems used in conventional packaged air conditioners. Pressure to advance technologies in areas such as efficiency and environmental impact, however, are leading to the development of new technologies for the air conditioner market.

A consortium of companies, including major air conditioner industry players like Carrier Corporation, DuPont, and Lockheed-Martin, formed recently to investigate potential advancements in the commercial air conditioner market. They have developed an innovative centrifugal compressor featuring numerous benefits over current technologies. The compressor, however, requires a much higher RPM drive than is currently available. SatCon Technology Corporation, also a member of the consortium, was assigned the task of developing a motor capable of meeting this challenge.

SatCon Technology has developed a prototype permanent magnet motor, and an advanced power electronic building block (PEBB) to control it, that replaces more complex power electronic circuits with a single device. The PEBB should have a power density of 400 watts per cubic inch, and the design may ultimately lower the cost of power electronics by as much as 50 to 70 percent. The resulting prototype drive turns 47,000 RPM and delivers 28 horsepower at full load with 93 to 95 percent motor efficiency.

Permanent Magnet Motor Drive System Specifications

Motor	Efficiency:	≥93-95% at full load; <5% drop off at partial load
	Cooling:	hydrofluorocarbons (HFC) 134a
	Rotor Diam.:	1.8”
	Cost/HP Goal:	$10 (not including assembly)
Power Electronics	Efficiency:	>96%
	Cooling:	air or water
	Dimensions:	20" x 24" x 9"
	Cost/HP Goal:	$30-$35
Overall Drive	Efficiency:	89%
	Supply Voltage:	440, 60Hz
	Reliability:	30,000 hour lifetime

Applying a high-speed permanent magnet motor drive system to operate vapor compression air conditioning systems can lower air conditioning costs from 10 to 15 percent per year.

Project Description

Goal: Develop and test a prototype that confirms the efficiency and performance of the high-speed drive and electronics and reduces risk associated with commercialization of high-speed technology for centrifugal compressors.

Since rooftop air conditioners were introduced decades ago, AC motors have been driving their compressors. Only a few minor modifications have been made to these systems over the years. However, concern over environmental impacts of energy use and growing market demand for cooling are stimulating investment in making air conditioning systems more efficient. Meanwhile, worldwide pressure to improve efficiency performance and minimize the environmental impact of products has sparked the need to rethink the delivery process of cooled air.

SatCon Technology's high-speed motor drive uses permanent magnet technology to deliver the power required to drive a prototype compressor system for a packaged rooftop air conditioner currently under development. Using rare earth permanent magnet materials, permanent magnet motors are significantly smaller and quieter than traditional AC motors and up to 15 percent more efficient, in part because they are able to operate at variable speeds. The motor currently being tested for use in commercial air conditioners is able to operate at speeds up to 47,000 RPM.

SatCon Technology Corporation is developing this new technology with the help of a grant funded by the Inventions and Innovation Program in the Department of Energy's Office of Industrial Technologies.

Progress and Milestones

In early 2000, SatCon Technology completed the Department of Energy funded phase of testing and performance verification of its high-speed permanent magnet motor drive. It made significant progress comparing two technologies to wrap the rotor, found one to be superior, and delivered a motor to Carrier Corporation for testing. Its test results normalized to operational conditions showed that its permanent magnet high-speed motor drive would cost slightly more than an induction motor, but would be 3 percent more efficient and have a power factor 5 percent higher. Reviewing cost elements for drives, SatCon Technology found more potential to lower costs in the power electronics portion of the system, which amounts to approximately 70 percent of total drive cost. Post-grant work is continuing on lowering the electronic control initial cost.

Economics and Commercial Potential

The market for commercial rooftop air conditioners is substantial. In 1995, approximately 368,500 commercial buildings in the United States were large enough to be candidates for replacement cooling systems of the type that SatCon Technology's product fits. In addition, it is estimated that around 15,000 new, large commercial buildings are constructed each year in the United States. These buildings are also candidates for the new technology. The higher efficiency and lower installation footprint for a centrifugal compressor AC system powered with a high-speed drive should repay higher initial costs in 12 to 30 months. However, the building market remains too focused on initial system-installed costs ($/horse-power), even though operating costs will dwarf first costs.

The next step for SatCon Technology is to complete development of a lower cost power electronics package for the permanent magnet motor product and position it to outperform competing induction motor technology. If it is determined that the permanent magnet motor should be used in the centrifugal compressor system, planning can begin for production and supply of the motor to air conditioner manufacturers. Alternately, if permanent magnet technology is not chosen for the air conditioner industry, other applications for the motor are available due to its size, noise, and efficiency advantages.

The Inventions and Innovation Program works with inventors of energy-related technologies to establish technical performance and conduct early development. Ideas that have significant energy savings impact and market potential are chosen for financial assistance through a competitive solicitation process. Technical guidance and commercialization support are also extended to successful applicants.

Project partners

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