Ultra-Efficient and Power-Dense Electric Motors

Advanced Electric Motors Offer Large Energy Savings in Industrial Applications

Pumps, fans, and compressors use more than 60% of industrial electric motor energy in the United States. The most widely used motors in these applications are constant-speed motors that are started and run across the line. In some applications, variable-speed motors, powered from an open-loop variable-speed drive, are utilized without any rotor position feedback device to achieve more energy-efficient system operation when flow control is desirable.

Induction motors are the workhorses of industry and represent nearly the entire installed base of constant-speed and most variable-speed motors. In the United States, induction motor efficiency for new industrial motor sales falls into two categories: energy-efficient motors that meet the requirements of the 1992 U.S. Energy Policy Act, and National Electrical Manufacturers Association (NEMA) Premium® efficient motors that have even higher energy efficiency levels. NEMA Premium® motors are heavier and have more active material than energy-efficient electric motors.

New motor technology is under development that may increase motor efficiency while reducing the size and weight of the motor by reducing the amount of active material used. This technology has become economically viable for some variable-speed motor applications and over a wide-rated horsepower range. However, its ability to be utilized in general-purpose industrial applications has been limited by the need for a variable-speed drive with a rotor position feedback device to allow for stable operation at any speed.

This project will create a low-loss, high power density industrial motor that is easy to install and use and more efficient, lighter, and smaller than current alternatives, including energy-efficient and NEMA Premium® motors. It will be a general-purpose motor that can replace existing induction motors for a wide range of line-start and variable-speed applications. The motor will have the ability to be started and run across the line or operated from a standard (volts/hertz) drive without the need for a rotor position feedback device.

Fan and pump industrial motor installations

Photos courtesy of Baldor Electric Company.

Benefits for Our Industry and Our Nation

The introduction of ultra-efficient and high power density electric motors has the potential to obtain a 30% reduction in motor losses as compared to NEMA Premium® induction motors. This exceeds the original project goals of a 30% reduction in losses compared to an energy-efficient motor.

These ultra-efficient motors will be 30% smaller in volume, 30% lower in weight, and have a higher power factor than NEMA Premium® induction motors, thereby driving rapid market penetration into user and original equipment manufacturer markets.

Applications in Our Nation's Industry

The across-the-line starting, ultra-efficient motors will be designed to replace constant-speed induction motors and variable-speed induction motors. Target applications will be pumps, fans, and compressors with motor ratings from 20–500 hp. It is estimated that 90% or more of the commercial and industrial applications will be suitable for conversion.

The smaller motor size and weight will keep the cost of these motors low enough to allow for rapid market penetration in a wide range of U.S. industries.

Project Description

The goal of this project is to develop line-start and line-run constant-speed electric motors and simple-to-control electric motors that use less energy than existing NEMA Premium® Efficient induction motors.

Barriers

- Analysis of the starting performance of these new motors is a unique technical challenge.
- The technical capability of larger line-start and open-loop controllable motors has been demonstrated through a number of laboratory prototypes in the 30 to 75 hp rating range. Design tools to predict the starting capability and transient performance of these motors are under development but not yet fully verified. Line-start characteristics must be tailored to meet customer needs.

Pathways

Project objectives will be accomplished by taking the knowledge learned from the current, laboratory prototypes and applying it to the design and demonstration of a number of motor prototypes that are optimized for cost and performance. Computer simulation and design tools are under development to predict the starting characteristics and to allow for design optimization. The design tools are being verified with tests on laboratory prototypes (50 hp and 150 hp) that are designed to meet the requirements of project team members Colfax Americas and Howden Fan Equipment. Project success will be measured by the energy efficiency and power density levels achieved and by the ability to predict the starting and steady-state performance of the prototype motors based on laboratory testing of both line-start and open-loop controllable motors.

The last phase of the project will include designing and manufacturing prototype motors to be married with a Colfax pump and a Howden fan and installed in an application at a project team member's end-user facility.

Milestones

This project started in October 2008.

- Development of computer models and design, building, and laboratory testing of prototype motors of a nominal 50 hp rating and 150 hp rating (Completed laboratory testing on 50 hp motor)
- Development of manufacturing technology
- Determination of maximum applicable horsepower (up to 500 hp) and maximum speed capability
- Completion of cost/benefit analysis
- Design, building, and laboratory testing of prototype motors for at least two end-user applications
- Installation of prototypes into end-use applications and monitoring of performance

Commercialization

Technology transfer will naturally occur through the well-established product commercialization channels within Baldor Electric Company. Baldor Electric products are sold into nearly all industrial applications, including those in the power generation, petroleum and chemicals, forest products, metals, food, aggregates, mining, material handling, heating, ventilating, air conditioning, wastewater, air handling, and beverage industries.

Project Partners

Baldor Electric Company
Greenville, SC
Principal Investigator: Rich Schiferl
E-mail: rfschiferl@baldor.com

Stephen D. Umans
Belmont, MA

Colfax Americas
Monroe, NC

Duke Energy Carolinas LLC
Huntersville, NC

DuPont Engineering
Moncks Corner, SC

American Electric Power
Columbus, OH

For additional information, please contact

Stephen Sikirica
Technology Manager
U.S. Department of Energy
Industrial Technologies Program
Phone: (202) 586-5041
E-mail: stephen.sikirica@ee.doe.gov

U.S. DEPARTMENT OF ENERGY
Energy Efficiency & Renewable Energy

EERE Information Center
1-877-EERE-INFO (1-877-337-3463)
eere.energy.gov/informationcenter

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