Trends in Variable Speed Technology

Tom Aloor, Nidec Motor Corporation

Choose the right variable speed motor for specific equipment.

Why and how do leading OEMs choose a variable speed motor for their equipment? While rated efficiency has been an important driver in the past and will continue to be one in the future, leading equipment and machinery manufacturers now use sophisticated variable speed technologies to radically redefine their products.

The developments in this field throughout the past decade allow OEMs to create smaller machines with greater functionality, fewer wear parts, higher uptime and much lower total cost of ownership (TCO) for the user.

In a rapidly globalizing business environment, every tool in the kit must be used—a custom motor and control system perfectly optimized for your machine may be one important tool.

The traditional approach to applying variable speed was to take the current equipment, change out the motor (if needed) and connect a variable frequency drive (VFD) with some outer-loop control scheme. This provided some gains in efficiency and other process parameters.

In addition to operational cost savings from optimizing to the process needs, hydraulic and pneumatic lines would not be subject to strenuous pressure cycles, accumulator requirements could be lowered, process leakage could be minimized, pumps could avoid cavitation and water-hammer effects, etc.

Most equipment end users and buyers now take these attributes for granted and wonder, "What else can your widget do for me?" Some simple, real-world examples illustrate how some leading OEMs are answering that question.

Figure 1. Positive displacement blower by Universal Blower Pac using a switched reluctance (SR) motor

Mature Technology

Custom-engineered switched reluctance (SR) motor-drive packages have been used on screw compressors and pumps and in other applications for several years by leading OEMs, primarily in Europe. With about 10,000 units installed in applications around the world, this mature technology has now drawn renewed attention from forward-thinking end users and equipment manufacturers as the importance of efficiency over true operating cycles (versus full-load or full-speed efficiency) gains recognition.

Universal Blower Pac manufactures blower systems for use in wastewater treatment. These systems are used to provide air at pressure for mixing or diffused aeration for a biological process. The air demand for these processes is typically variable on a daily basis and significantly variable over the lifespan of the facility as population density and plant demand fluctuate.

To meet the variable demand, the company has always used VFDs with induction motors to optimize blower system capacity. However, VFDs and standard motors encounter significantly reduced efficiency off their base frequency or under partial load. Switched reluctance (SR) technology allows Universal Blower Pac to integrate into its EE-PAC control panel the ability to operate the unit across a wide range of operation and loads.

"This significantly increases the efficiency and reduces the cost to operate our blower systems and provides a drastic improvement over VFD/induction motor systems when we have a variable load," says Andrew Placek, lead WTP sales engineer, Universal Blower Pac. "The EE-PAC is 40 percent more

efficient than a standard blower system using a traditional VFD and induction motor arrangement."

Increase Efficiency

Figure 2. Variable speed BPM pool motor with user interface

In recent years, new technologies have been embraced and adapted to greatly increase the efficiency of filtration pool pumps. The application of variable speed pump technology and as retrofit motors on pumps has increased energy savings potential.

Programmable timers allow for peak avoidance, which can also benefit consumers and utilities.

The basis of the technology is brushless permanent magnet (BPM) motors that increase the static efficiency of the application and can decrease the size of the motor, as well as heat generated in the application. A significant portion of the energy savings is realized by the motor and drive efficiency and by the integration of smart controls that precisely control the pump operation and cycling. One estimate is that the adoption of variable-speed pumps on all in-ground pools in the U.S. could result in a savings of nearly 2,000 megawatt-hours per year. (This estimate is based on 4.9 million pools, operating 8 months per year, 11 hours per day.)

The technology and configurations developed for this pool market with compact BPM motors and drives are already being used in related applications to increase static and system efficiency. Several applications in both residential and commercial pumping can benefit from the use of similar technology with a new interface or control.

No More Poles

Most centrifugal pump designs have centered on induction motor pole speeds—volutes were designed for two-, four-, six-, or eight-pole (or slower) motor operation. While you can design pumps with best efficiency points (BEPs) at speeds different from pole speed and then run a motor super-synchronous or sub-synchronous, the loss in motor system efficiency made this sub-optimal.

Fairbanks Morse Pump (a division of Pentair), a leading OEM, was looking for a radical alternative to a high-pressure pump design. The conventional arrangement used a 16-stage pump with a 3,600-rpm variable-speed induction motor to deliver 300 gallons per minute at 1,000 psi. This arrangement has been the norm for this application for a long time—"grin and bear it" was the attitude.

Not only did end users have to accept low pump and system efficiency, but they also had to deal with a long barrel of a pump assembly (16 stages) with associated alignment and maintenance issues. The best-case system efficiency was

Figure 3. A four-stage, 300-gallon-per-minute, 500-psi pump by Fairbanks Morse with 6,600-rpm, 120-horsepower SR motor

typically 69 percent at base speed (76 percent pump efficiency x 95.4 percent full-load motor efficiency x 97 percent VFD efficiency x 0.98 percent harmonic loss factor). This efficiency deteriorated significantly when the speed was lowered by up to 10 percent to maintain the process variable.

Fairbanks Morse Pump decided to try something new—a six-stage pump directly coupled to an SR motor running at 8,000 rpm. While running at this speed required careful material selection and design for impellers and diffusers, the resulting benefits were plentiful. System efficiency was up by more than 5 points to 74.5 percent (81 percent pump efficiency x 92 percent SR system efficiency).

The number of pump parts reduced by almost two-thirds. Alignment was significantly less arduous, and the motor efficiency stayed virtually unchanged across the operating speed/load range. The end user not only received a smaller package size with fewer parts and easier maintainability but also enormous energy savings over the life of the equipment.

While in this case a higher speed controlled motor (with a flat efficiency curve) was the solution, several other pump applications call for the opposite end of the spectrum—slow speeds with flat efficiency curves.

Large slurry pumps that traditionally used gearbox reduction to run at 100 to 400 rpm can now use the same SR technology motors to directly drive the impeller. The results are a smaller, more efficient package with higher uptime and lower maintenance costs.

Variable Speed Systems Have Matured

Taking a new approach through the design or redesign of their equipment can benefit OEMs by allowing them to break out of the mold and evaluate radically new solutions using variable speed. While equipment purchase price will always be firmly on the capital equipment buyer's checklist, TCO grows in importance each day as the true costs of energy, maintenance and down-time increasingly determine winners and losers.

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Tom Aloor is the director of business development for Nidec Motor Corporation, Saint Louis, Mo. He can be reached at tom.aloor@nidec-motor.com or 314-595-8286. For more information about Nidec, go to www.nidec-motor.com.