Magnetically Coupled Adjustable Speed Motor Drives

Suggested Actions

- Complete a survey to identify constant speed motors in your plant that are used to drive centrifugal pumps with throttling valves or recirculation (bypass) lines or centrifugal fans equipped with inlet and/or discharge dampers.
- Determine the load profile for systems that are in use for more than 2,000 hours per year.
- Determine the energy savings and cost effectiveness of installing an electronic ASD or magnetically coupled ASD motor controller.
- Consider magnetically coupled ASDs for intermediate voltage motors, when sensitive equipment cannot tolerate harmonic currents, or where maintenance requirements are high due to load vibrations being transferred to the motor bearings.

Resources

U.S. Department of Energy—For additional information or resources on motor and motor-driven system efficiency improvement measures, visit the BestPractices Web site at www.eere.energy.gov/industry/bestpractices, or contact the EERE Information Center at (877) 337-3463.

National Electrical Manufacturers Association (NEMA)—Visit the NEMA Web site at www.nema.org for information on motor standards, application guides, and technical papers.

Adjustable Speed Drive Overview

Alternating current electric motors rotate at a nearly constant speed that is determined by motor design and line frequency. Energy savings of 50% or more may be available when fixed speed systems are modified to allow the motor speed to match variable load requirements of a centrifugal fan or pump.[1]

Loads that vary over time by 30% of full load offer good opportunities for cost effective adjustable speed drive (ASD) retrofits. Market assessment studies indicate that in light and medium industry 26% of motors exhibit fluctuating loads; 22% of these are in process industries and 35% are in other heavy industries.[2] However, ASD installations remain low (7%–13%). The majority of ASD-equipped industrial motor systems are of 20 hp or less—with the ASD often installed for improved control over the production process rather than energy savings.

Electronic ASDs

The current state-of-the-art speed control is the electronic ASD. Because of their energy efficiency and control capabilities, electronic ASD and motor combinations have replaced constant speed motors in virtually every type of industrial plant. Although electronic ASDs have been available for more than 20 years, they are not suited for all applications. For example, an estimated 15% to 20% of industrial plants use medium voltage (>600 to 6600 volts) to supply power to motors rated as low as 250 hp. Semiconductors for medium voltage motor applications are particularly expensive. Depending on the situation, other factors that can discourage electronic ASD use include:

- Creation of harmonics (requiring installation of line reactors or harmonic filters)
- Voltage spikes (leading to early motor failure)
- Motor bearing failures due to currents induced in the motor's rotor that flow to ground through the bearing
- Nuisance tripping
- Limitations on the distance that ASDs may be installed from the motor.

Magnetically Coupled ASDs

In contrast to an electronic ASD, a magnetically coupled ASD does not alter the power supplied to the motor. With a magnetically coupled ASD, the motor is generally brought up to operating speed while unloaded. The motor continues to operate at its rated design speed while the magnetic coupling controls the torque transferred and the speed of the driven equipment by varying the strength of the magnetic field between the motor shaft and the load shaft. The strength of the magnetic field is controlled by varying the width of an adjustable air gap or by varying the amount of current applied to an electromagnet.

Because the load and motor shafts are not directly coupled in magnetically coupled ASDs, vibrations that occur on the load side are isolated and not transmitted to the motor. For instance, a newsprint products plant recently installed a magnetically coupled ASD for a 250 hp/2300 V motor running a centrifugal pump with a bypass flow control valve. This project resulted in annual energy savings of 633,000 kWh. Long-term maintenance costs decreased as pump cavitation was eliminated and vibration was dramatically reduced.[3]

Magnetically coupled ASDs do not have to be housed in a controlled environment. They allow for multiple motor starts with no "cool-off period" and are desirable where harmonic distortion cannot be tolerated or where poor power quality would result in excessive nuisance trips. Load seizure protection is also inherent with this design. Because magnetic coupled ASDs operate independent of motor power supply voltage, they are often cost-effective in applications with medium voltage power supplies. Other advantages include: compatibility with existing standard efficiency motors; avoidance of additional motor heating and the need for motor de-rating; and accommodation of shaft thermal expansion.

Disadvantages of magnetically coupled ASDs include space and weight constraints. Some are not compatible with vertical shaft motors or belt-driven loads. They are also maintenance-intensive and require repair by technicians with specialized training.

Magnetically coupled ASDs offer some operating advantages that are desirable for niche applications by providing speed control that can be up to 30% more efficient than damper fan control and 44% more efficient than throttled pump control. However, they capture only about 60% of the energy savings obtainable with conventional electronic ASDs. Savings decrease as the turndown increases.[4]

References

1. ADM Associates, Inc., "Adjustable-Speed Drive Case Studies," prepared for the Wisconsin Center for Demand-Side Management, 1994.
2. Xenergy, Inc., *United States Industrial Motor Systems Market Opportunities Assessment,* prepared for the U.S. Department of Energy's Office of Industrial Technologies, December, 1998.
3. Northwest Energy Efficiency Alliance, *Field Testing the MagnaDrive Coupling Speed Control Technology on Northwest Industrial Applications,* "Case Study: Ponderay Newsprint, Usk, Washington" 2000, www.nwalliance.org/research/documents/MagnaDriveCS_Pnderay2.6.pdf
4. Motor Systems Resource Facility, Oregon State University, "Product Testing: MagnaDrive, Report No. 1," Prepared for the Northwest Energy Efficiency Alliance, March, 2000, www.nwalliance.org/resources/reports/00-048.pdf

Dan Greenberg, *Platts Research and Consulting,* "Magnetically Coupled Adjustable-Speed Drives: Going Where No VFD Has Gone Before," ER-03-18, November, 2003.

Quantec, "Market Progress Evaluation Report: MagnaDrive, No. 2," prepared for the Northwest Energy Efficiency Alliance, Report E02-099, May, 2002.

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