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Magnetic drives optimize performance

*They can tackle
big problems*



Power Transmission



Figure 1. Fully assembled magnetic adjustable-speed drives with magnet rotor assembly inside conductor assembly.

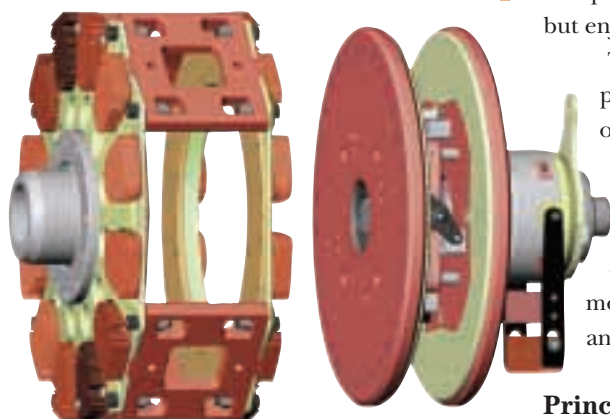


Figure 2. Dis-assembled drive showing magnet rotor assembly removed from conductor assembly.

By Ken Black, P.E.

In tough economic times, thin margins compel managers to seek innovative ways to reduce operating costs. Reducing continually escalating energy costs is receiving a heightened focus and priority. At the same time, the ability to achieve precise control, improve process efficiencies and reduce total life cycle costs of industrial equipment are equally important objectives.

The ability to regulate the flow of air, fluids and other materials accurately is critical to both quality control and cost containment. Traditional process control has been achieved with throttling devices such as control valves, dampers and belt systems. But, these devices are inherently inefficient because they operate by choking the flow while a motor is still driving a pump or fan at full speed. This is equivalent to using the accelerator and brake simultaneously to control an automobile's speed.

The need for energy-efficient process control led to the development of adjustable-speed drives (ASDs). In industrial pump, fan and blower systems, where loads can vary, ASDs provide variable speed (flow) control while reducing the energy the motor consumes. The most widely used ASD is the variable-frequency drive (VFD). Since its introduction in the mid-eighties, it has driven ASD market acceptance and garnered a dominant share of the ASD market because of its energy savings. The VFD will continue to be an appropriate choice for many motor applications, notably those of 20 hp and below, in which they not only are cost effective, but enjoy significant market penetration.

The problem in the United States, however, is that 85 percent of motor energy is consumed by units of 20 hp or greater. Moreover, this segment has relatively little ASD penetration and can benefit from increased energy efficiency. VFDs are not necessarily cost effective in higher horsepower applications where complexity, reliability, installation, maintenance, harmonic distortion and power quality issues can wipe out any energy savings achieved.

Principles of operation

Magnetic adjustable-speed drives are an alternative to inefficient throttling devices and complex electronic VFDs. They use permanent magnets of neodymium, iron and boron (NdFeB) to transmit torque across an air gap, which eliminates the physical connection between the motor and driven equipment. The motion of the magnets induces eddy currents in a copper plate, which then transmits torque.

Varying air gap width changes the degree of coupling, producing a controlled and infinitely variable output speed. This allows precise, efficient, modulated speed control for

optimum performance, including soft starts. With no direct connection between motor and load, the magnetic ASD tolerates misalignment and minimizes costly wear-and-tear vibration.

Figure 2 shows the basic configuration of the device. Two discs, steel-backed with copper faces, are connected together and rotate

under motor power. Between the plates and attached to the load shaft are two aluminum discs holding an array of permanent magnets polarized in the axial direction. The aluminum plates also move axially, which controls the air gap between the magnets and the copper plates.

When the magnet assembly

rotates, relative slip induces eddy currents in the copper discs, which enables torque to be transmitted without physical contact. Controlling air gap width between magnets and conducting discs controls the rate of change of magnetic flux linkage of the conducting discs, which, in turn, controls the amount of applied torque. When the air gap is at its smallest, the resulting strong degree of coupling minimizes relative slip and maximizes the driving torque. An actuator working off a 4-20 mA or other control signal modulates the air gap and, in turn, the ASD's speed or torque output.

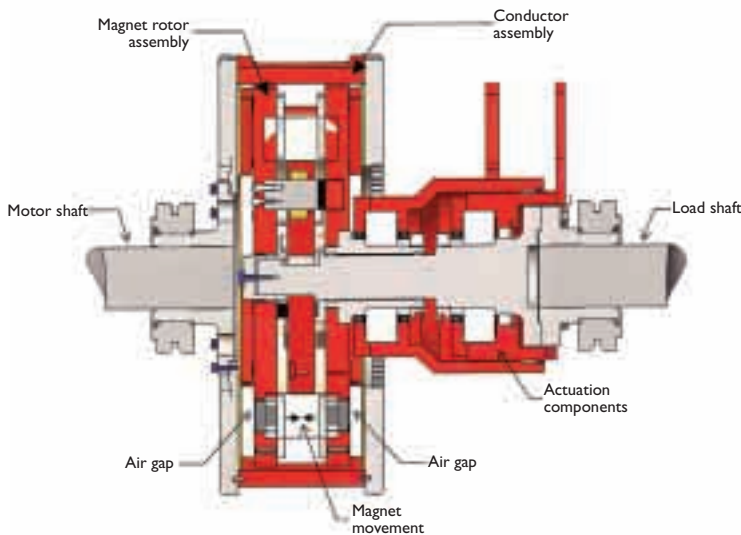


Figure 3. Cross section of a magnetic ASD showing magnet rotor assembly attached to load shaft and conductor assembly attached to motor shaft.

Motor start-up current Magnetic ASD vs. Belt drive

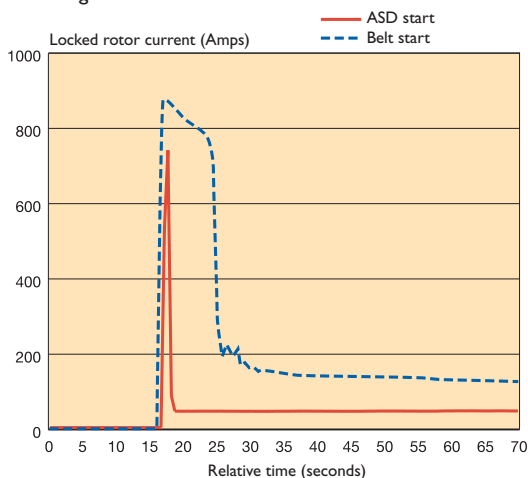


Figure 4. Motor start-up locked rotor current over time for a 125-hp motor and fan. The dashed blue line represents a typical hard start with a motor coupled to the fan through belts. The curve shows peak start-up current in excess of 875 amps (equivalent to 975 hp at 480 volts and three-phase) for duration of 10 sec. The solid red line shows that the magnetic ASD reduced the duration of locked rotor current to 1.5 sec, while reducing no-load running current from 142 to 49 amps, which saves energy when fan is not needed.

Installations

The magnetic ASD is well suited to driving variable loads—notably pumps, fans and blowers—in applications from 10 hp to 1,500 hp in new or retrofit installations. It's not recommended, however, for constant torque applications because large amounts of slipping eddy currents generate significant heating in the ASD.

The magnetic ASD can be used in either a direct-drive or belt-driven connection, in both horizontal and vertical orientations. For direct drive, the motor must be moved 12 in. to 18 in. further away from the load to provide space for the ASD. The conductor assembly is bolted to the motor shaft and the magnet rotor assembly is bolted to the load shaft.

The ASD can tolerate a greater degree of misalignment than would be appropriate for a hard connection between motor and load. Belt-driven application either can be converted to direct-driven or have a pulley added to the output shaft.



Power Transmission



Magnetic ASD installation with a 125-hp 1,800 rpm motor and centrifugal fan. The ASD saves 155,000 kW-h of energy and \$10,000 on maintenance costs annually.

Benefits

The physical separation in the drive offers several advantages. The motor can be started and engaged gradually for a soft start. This avoids having to deal with locked rotor current, motor heating, start-up brownouts and peak power demand charges. (Figure 4) It can allow for motor downsizing to meet running—rather than starting—requirements. The ASD tolerates gross parallel and angular misalignment, simplifies installation and eliminates vibration transfer. Bearings and seals last longer, extending equipment life.

In systems audited, the magnetic ASD reduces energy consumption anywhere from 25 percent to 66 percent in comparison to traditional throttling systems. It also eliminates vibration problems caused by turbulent flow, vibration and water hammer that occur in throttled systems.

The magnetic ASD also can be an attractive alternative to a VFD,

which, though energy-efficient, is complex and costly to install and support in many applications. Unlike VFDs, magnetic ASDs generate no electronic harmonics, and they are unaffected by power quality.

Because VFDs require a hard link between motor and load, they don't solve vibration, wear and alignment problems the magnetic ASD eliminates. In higher-horsepower or medium-voltage applications, VFDs can be prohibitively expensive. And finally, a typical VFD has a life expectancy of eight to 10 years compared to more than 30 years for a magnetic ASD.

Its elegant simple technology and benefits led IndustryWeek magazine to recognize the magnetic ASD as a Technology of the Year for 2001.

A new standard for industrial couplings

A technology that provides torque transfer while isolating the motor from its load has applications

beyond speed control. It can be used for over-torque prevention couplings for constant-speed applications, ranging from 10 hp to 1,000 hp. Examples include conveyors, compressors and many types of manufacturing machinery. These systems operate with standard industrial couplings that comprise a hard link between the motor and its load. They suffer from vibration and alignment problems, equipment failure and downtime.

The magnetic couplings eliminate the need for laser alignment and significantly reduce vibration transfer, equipment damage and downtime. Further, they are nearly maintenance free, requiring only an annual inspection that can be performed while equipment is operating. Finally, in torque overload situations where material jams the system or is too heavy, the magnetic couplings automatically disengage, shutting down the system and preventing damage or even destruction of the motor and driven equipment. When the jam is cleared, the coupling automatically resets itself to resume operation.

The technology also appears to have potential in vehicles as a clutch substitute, a continuously variable transmission, a constant-speed drive to power alternators and superchargers, a variable-speed drive for fan clutches, differentials and accessory drives and as a dynamic braking system. Ⓢ

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Figures and photo: MagnaDrive Corp.