Eliminating Magnetic Encoder Interference from Brakes

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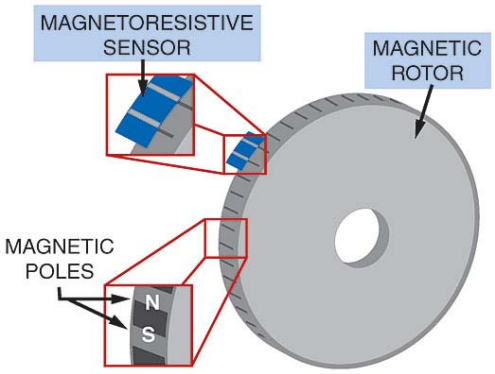
INTRODUCTION

Magnetic encoders use a sensor to detect the movement of one or more magnets. Their electronics produce output in proportion to speed and/or distance traveled. So what happens when a magnetic encoder mounted on a motor is placed next to a conventional brake, one that uses powerful magnetic solenoids or magnetic fields themselves to stop the shaft?



The answer isn't always good for the encoder. However, by selecting and applying components carefully, designers and users can eliminate most magnetic interference problems from brakes.

PROBLEM

Rotary magnetic encoders utilize sensors to detect the rotation of a magnetized ring attached to a rotor and shaft mechanism. Typically, sensors detect the orientation (and movement) of the magnetic lines of flux from the ring. The sensor data are fed to digital signal processors to produce a quadrature signal (A Quad B). These signals provide speed and position feedback.

The problem is that magnetic fields generated by brakes (and other magnetic fields) can distort or swamp the lines of magnetic flux from the rotor. This cause the encoder to partially or completely malfunction: It may produce no output at all, or it may produce the incorrect number of pulses for the real-world movement it is monitoring, or even output pulses while stationary!

Optical encoders seem like the obvious solution, but their durability in severe environments limits their use. With their reliance on seals to keep out dirt, dust and oil, optical encoders quickly fail in rough environments.

Even mounting the optical encoder inside the brake is not a perfect solution: The encoder is still exposed to heavy temperature cycling, which will break down the seals over time. Once brake dust or moisture enters the optical encoder, it will fail.

PROPOSED SOLUTION

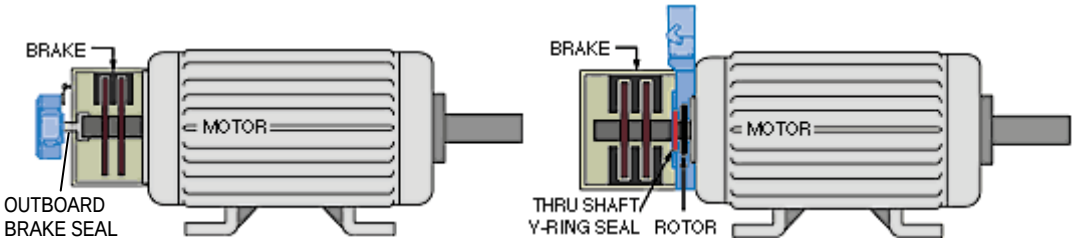
To eliminate magnetic interference, the installer and/or designer must combine:

- Knowledge of magnetic encoder construction
- Knowledge of brake types
- Flexible installation applications
- Experience with encoder brands

BACKGROUND

Motors, encoders, and brakes typically intersect on crane and hoist applications. Other motion control applications require this combination as well.

There are two common motor, encoder, and brake combinations used worldwide on heavy crane and similar installations:



"Motor-Brake-Encoder (MBE)" "Motor-Encoder-Brake (MEB)"

Motor-Brake-Encoder (MBE) combinations offer quick replacement of the encoder, but are not without problems. The outboard brake seal is a significant source of maintenance. It is frequently damaged by the shaft movement caused by the brake itself. The encoder is exposed to damage from any moving objects nearby. Hollow shaft or coupled solid shaft encoders must be used, which have bearings, another potential source of failure.

Motor-Encoder-Brake (MEB) combinations protect the encoder from external damage, and eliminate the encoder bearings through the use of a modular encoder. The outboard shaft seal on the brake is eliminated. The entire assembly is bolted together, end-to-end. This makes the MEB combination extremely low-maintenance and extremely impervious to damage. However, if the encoder fails, dis- and re-assembly can take hours.

Modular Encoders:

Modular encoders (also called pancake or C-face mount) are bearingless, two-piece designs. A rotor is mounted on the motor shaft. The stator contains the sensor and electronics. Inboard and

outboard C-faces provide alignment of the MEB sandwich, and bolts are passed through the brake frame, through the encoder stator bolt holes into tapped holes on the motor C-face.

Encoder models with removable sensors help solve the MEB disassembly problem. If the electronics are damaged, the user can simply replace the sensor without disassembling the MEB package. Only the rotor is inaccessible, and rotor failure is extremely rare.

Modular Encoders with removable sensors Front & rear views

Note that modular encoders are not well-suited to Motor-Brake-Encoder (MBE) configurations. The shaft deflection produced by the brake can cause the spinning rotor to contact the sensor, with disastrous results for the encoder. Even Avtron Wide-Gap modular encoders are not recommended for mounting outboard of a brake.

Hollow Shaft Encoders:

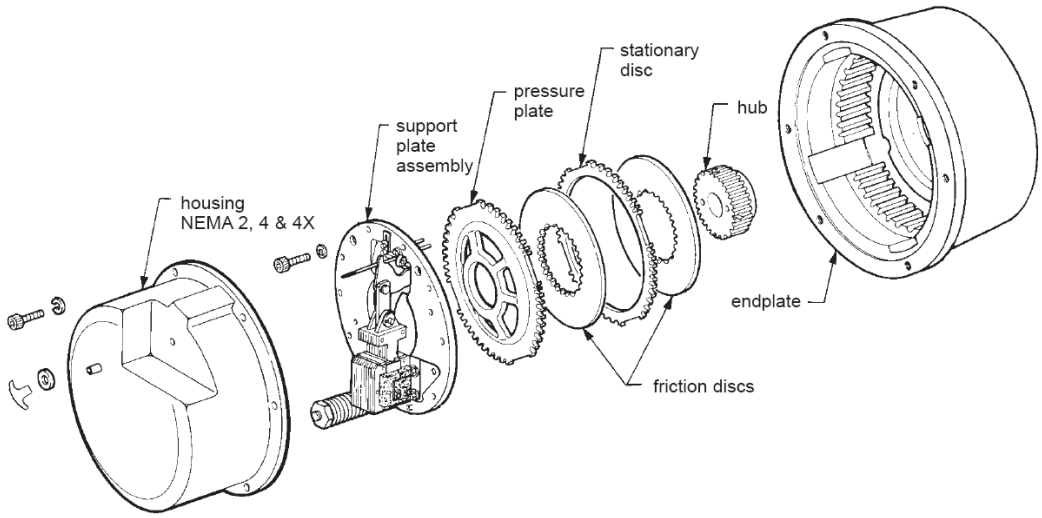
Hollow shaft encoders (also called tethered) grip the stub shaft extending from the brake (MBE configuration). A tether (antirotation arm) prevents the encoder housing from turning with the shaft. Replacement is quick and easy, but the encoder's exposed location behind the brake may result in damage and frequent replacement unless heavy duty encoders are used.

Severe Duty Hollow Shaft Encoder

Solenoid Actuated Brakes:

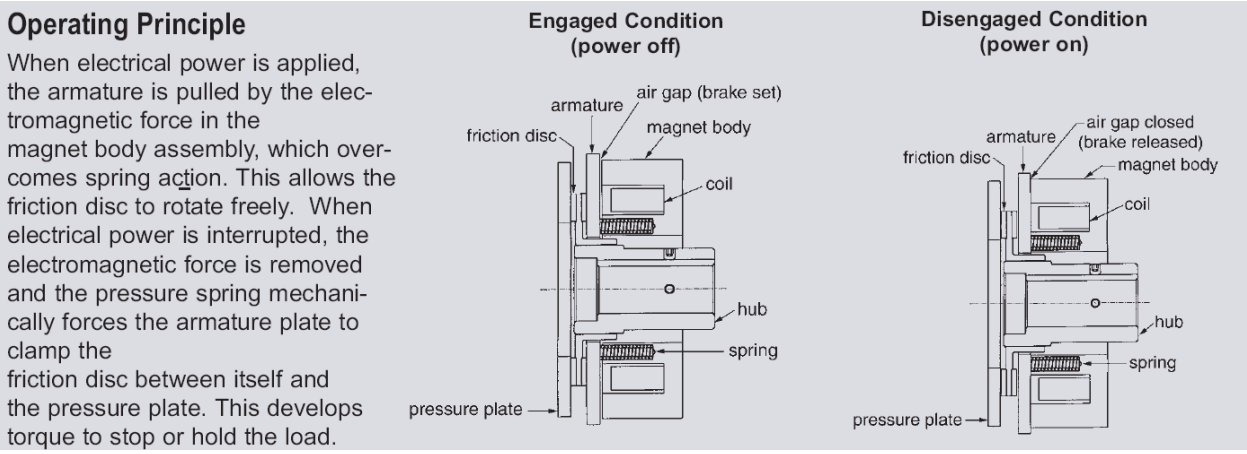
Solenoid actuated brakes instead use a lever arm and a solenoid to overcome spring action. This allows the friction disc to rotate freely until power is removed.

Self-Adjusting Disc Brakes - Main Components



(Source: Rexnord.com web site)

Armature Actuated Brakes:



(source: Rexnord.com web site)

Armature actuated brakes use far more powerful magnetic coils than solenoid actuated brakes. Also the magnetic fields are not contained by the shape of the brake coils in an armature actuated brake. This makes them a far more powerful source of magnetic interference than solenoid actuated brakes.

CASE EXAMPLES

Example #1:
A major crane and hoist controls manufacturer was experiencing intermittent problems with sandwiched modular encoders (MEB). These MEB packages used solenoid actuated brakes. After extensive testing, they concluded that the magnetic brake was causing intermittent extra "counts" from the encoder. When the coil of the solenoid was activated, the encoder would intermittently produce an output pulse, as though the sensor had seen encoder movement. However, since this test was performed with the rotor and shaft clamped rigidly in place, these "counts" were easily determined to be interference from the brake.

After extensively documenting the problem, the controls manufacturer performed in-house testing on several brands of encoders under identical test conditions. It was determined that Avtron Thin-Line encoders were not affected by the solenoid actuated brakes in use.

This controls manufacturer changed to Avtron Thin-Line encoders, and the problem of intermittent counts was solved.

Example #2:
An aluminum processor had installed a series of new hoist cranes with modular encoders (MEB) and solenoid actuated brakes. The newly installed encoders would not work at all at startup, due to a combination of magnetic fields from the aluminum process and the solenoid actuated brakes.

The processor replaced the encoders with Avtron M85 (now AV85) Thin-Line encoders, and the hoists worked perfectly without any other changes.

Example #3:
A paper mill had problems where older DC motors were heavily magnetized. Magnetic encoders used on these motors would provide fluctuating signals and drive trips.

Avtron's AV850 encoder includes advanced sensor technology, combined with magnetic shields to keep out external fields. The AV850 replaced the older models, without the signal fluctuations, and the customer's installation went from shaky to rock-solid-reliable.

Example #4:
A major brake manufacturer was seeking more reliable encoders to enclose inside their (solenoid-actuated) brakes. They were offering optical encoders only because of concerns about magnetic interference, as well as size constraints.

Tests with the brake proved that an Avtron HS35M magnetic encoder functioned properly while located completely inside the brake enclosure! No magnetic interference was noted, and the increased durability of the HS35M was attractive to customers and the brake manufacturer, given the temperature swings and brake dust that shorten the life of optical encoders.

SUMMARY: APPLICATION GUIDANCE TO AVOID MAGNETIC BRAKE INTERFERENCE WITH ENCODERS

First Guideline: Be aware that not all magnetic brakes create equal interference effects:

- Armature Actuated Brakes create far larger, more powerful magnetic fields; use solenoid actuated brakes where practical.

Second, if interference is a problem, more space may resolve the issue:

- Magnetic field density falls off proportional to the square of the distance from the source. Use wider encoders with smaller motor stub shafts, and larger rotor diameters (AV125 & AV850 vs. AV85, for example). This will keep the magnetic fields of the brake and a possibly magnetized stub shaft farther from the sensor of the encoder.

- Flange adapters and spacers can also be utilized to create more space between the magnetic interference source and the encoder sensor.

Third, magnetic shield systems make a huge difference. Manufacturers may also offer additional shielding upon request:

- AV45, AV125, AV485, AV685, AV850, & XP45 encoders have built-in shields to minimize interference. In addition, specially shielded sensors are available as an option for extremely powerful magnetic field applications.

Last, select manufacturers and models carefully:

- Beware of the immediate reaction to change to optical encoders: Optical encoder models are less durable than their magnetic counterparts. Quite simply, optical encoders come from the factory sealed-up to prevent contamination. With temperature cycling and moisture, optical encoders will eventually draw contamination into the encoder and malfunction, no matter what their IP rating. For tough applications, stay with a carefully selected magnetic encoder.

- Different manufacturer's magnetic encoder sensors have widely varying sensitivity; Avtron's experience shows that identical-appearing models do not have the same performance. In particular, Avtron models show a much greater ability to ignore magnetic interference than competitive models. Avtron Industrial Automation, Inc. produces a full range of magnetic encoders that are highly resistant to magnetic interference. A list of these magnetic encoders can be found in an attached appendix.

Appendix: Avtron Magnetic Encoders:

All Avtron magnetic encoders feature advanced sensor technology designed to ignore magnetic interference from outside sources such as magnetic brakes and motor magnetic fields.

Avtron Solid Shaft Encoders

With the large space created by shaft coupling to create Motor-Brake-Encoder (MBE) combinations, magnetic interference is rarely a problem for solid shaft encoders.

AV485: These heavy and severe duty magnetic solid shaft encoders have advanced sensor technology and shielding to eliminate the effects of magnetic interference. Their extremely heavy construction protects them from damage at the exposed location behind the brake.

Avtron Solid Shaft Encoders with isolation

Avtron Modular Encoders:

Modular encoders are highly protected from external damage when mounted in Motor-Encoder-Brake (MEB) combinations. Their bearingless construction gives them extremely long life; they have no contacting moving parts. MTBF can exceed 4,500,000 hours.

AV56, AV56S, AV67, AV85 & AV115: These Thin-Line heavy mill duty encoders have advanced sensor technology to ignore the effects of magnetic interference.

Avtron Modular Thin-Line Encoders

AV125 & AV850: These heavy mill duty encoders have advanced sensor technology to ignore the effects of magnetic interference. Moreover, their integral shields and larger rotor diameters provide further magnetic isolation.

Avtron Modular Encoders

Appendix: Avtron Magnetic Encoders (con't)

Avtron Hollow Shaft Magnetic Encoders:

Hollow Shaft Encoders are mounted outboard of the brake in Motor-Brake-Encoder (MBE) combinations which are convenient for quick replacement, but are more vulnerable to damage.

HS35M: This mill duty magnetic encoder features advanced sensor technology to ignore magnetic interference.

M4-3/F: These heavy mill duty encoders offer advanced sensor technology, combined with larger, wider housings which provides additional magnetic isolation.

AV685: This severe duty magnetic encoder features advanced sensor technology, and the largest, widest housing for the maximum protection from external magnetic fields. Magnetic shielding in standard, and specially shielded sensors are available.

XP45: This severe duty encoder includes advanced sensors, and integral magnetic shields.

Avtron Hollow Shaft Encoders