Brakes beat ball screw back drive

GENE W. POKER, Stearns, Rexnord Corp.

Though ball screws provide accurate positioning, they are susceptible to back driving. A spring-set brake is an effective way to stop back driving in a small space.

The growing demand for higher efficiency and greater positioning accuracy has led to increasing use of ball screws in many linear actuation applications, such as machine tools, material handling equipment, packaging machinery, robotics, satellite dishes, and medical equipment.

In particular, the push for energy savings often leads engineers to choose ball screws over Acme screws, even though ball screws cost more. The reason: lower friction in a ball screw saves energy, thereby reducing operating costs. Also, less friction often permits the use of a smaller motor, cutting both initial and operating costs.

But lower friction has one drawback. Unlike Acme screws, which have enough internal friction to hold their position, the low friction in ball screws tends to let them back drive under load. This makes a brake necessary in most vertical mounting applications, as well as some horizontal applications where vibration is present.

Friction brakes and wrap-spring brakes are often chosen because they're inexpensive and simple to install. But, by adding friction to the system, they negate some advantages of the ball screw actuator. The added friction also leads to wear, which can reduce long-term reliability, especially in heavy use applications.

Moreover, space limitations often make it difficult to find room for a conventional brake. One solution that works well is a compact spring-set electric brake applied to the drive motor.

***Gene W. Poker** is product manager-dc products, Stearns Div., Rexnord Corp., Milwaukee.*

Brakes on actuators

Thomson Saginaw Ball Screw Co., Inc., found the solution to ball screw back driving by applying an electrically released, spring-set disc brake to its Performance Pak Actuator, Figure 1.

Terry Shark, product manager for Thomson Saginaw explains "The brake doesn't interject more friction like a wrap-spring brake, so actuator life and duty cycle have increased dramatically. Because we're not driving through friction when the actuator is running, the ball screw is free-wheeling."

Each actuator contains an electric motor, gearbox, and precision ball screw assembly. Depending on the model, these units provide strokes of 4 to 36 in. for loads of either 500 or 1,500 lb. The brake, with a static torque of 7 lb-in., mounts on the auxiliary motor output shaft. It provides both dynamic braking and position holding.

Actuators fitted with the spring-set brakes have operated trouble-free for 2½ years. The company expects a minimum of 300,000 brake cycles between servicing intervals, about ten times more than with a wrap-spring brake.

Spring-set, electrically released brakes develop braking and holding torque in the absence of electrical power, Figure 2. Power to the brake causes a magnet to overcome the spring clamping force between friction disc, armature plate, and pressure plate, letting the disc move freely. When power is interrupted, the spring forces the armature plate to clamp the friction disc between itself and the pressure plate, thereby stopping the actuator to which the brake is mounted.

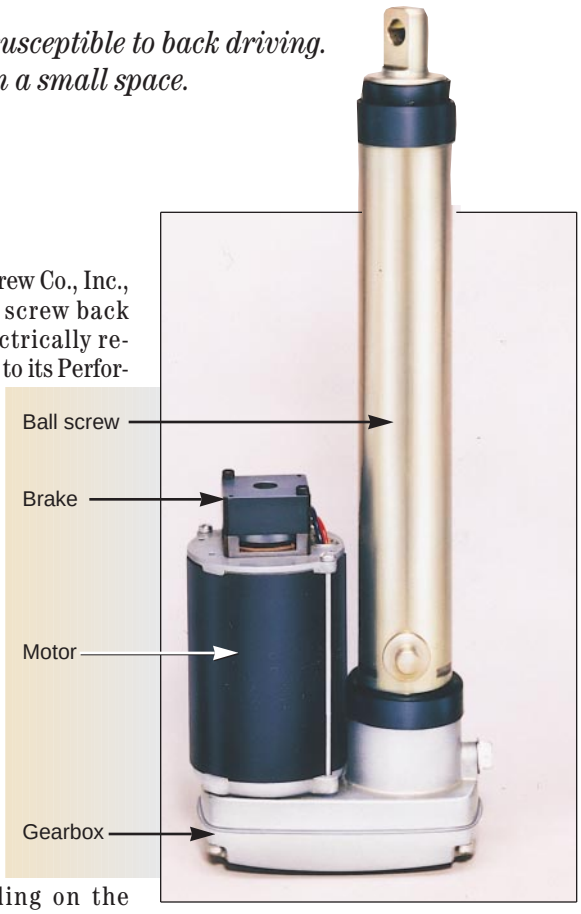

Figure 1 — Performance Pak Actuator with spring-set electric brake. Cover is removed to show the brake.

The use of spring-set brakes is not limited to ball screw applications. Prime application candidates include other types of motor-driven actuators used on medical equipment, robotics, material handling systems, automated guided vehicle systems, and door or partition systems.

continued on page 37

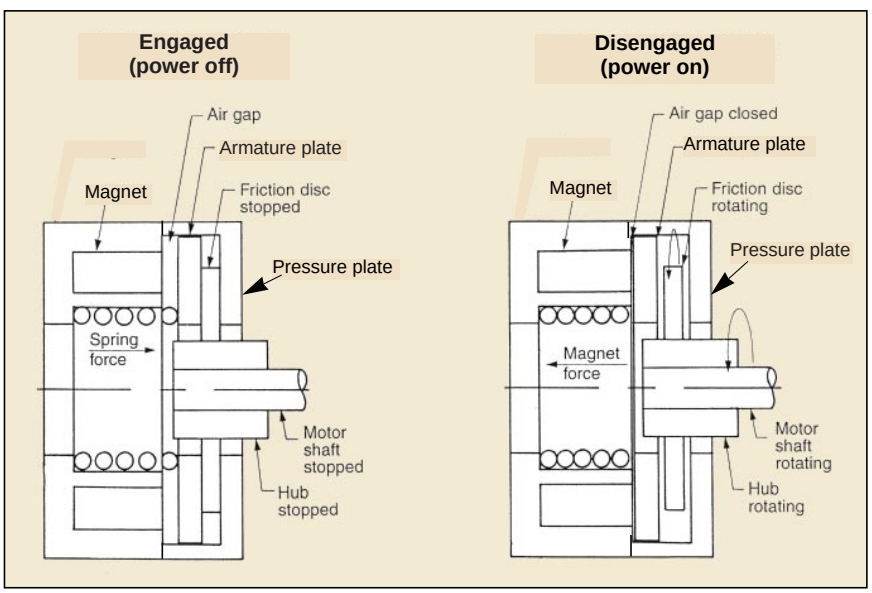

Figure 2 — Electrical power causes the magnet in a spring-set brake to pull an armature plate away from the friction disc so it is free to move. When power is interrupted, the spring forces the armature plate into clamping contact with the friction disc and pressure plate, thereby applying the brake.

Brake characteristics

Spring-set disc brakes, Figure 3, have several characteristics that make them well-suited for ball screw actuators. With body lengths of about 1¼ to 2¼-in., they require less space than other electrical brakes. They generally have higher thermal capacity than other designs (typically 1.8 to 5.0 hp-sec/min, or 990 to 2,750 lb-ft/min). Also, this type of brake is sometimes built into the motor housing to enhance actuator appearance and conserve space.

These brakes typically require minimal electrical power, about 6 W. Versions are available to operate on several ac or dc voltages. There are also hubless designs that enable driving the friction disc directly from a motor shaft, which simplifies mounting and eliminates the need for alignment.

Standard brakes allow 1.5-deg backlash, which may not be adequate for applications requiring high positioning accuracy. Such cases may require a special model with near-zero backlash.

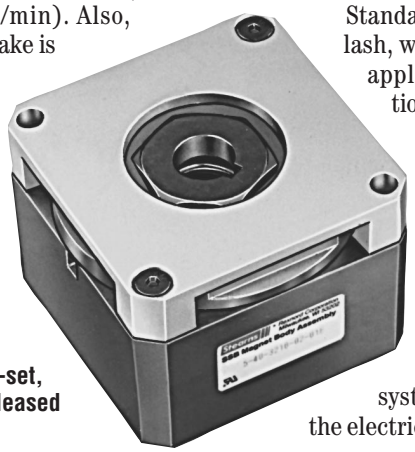

Figure 3— Typical spring-set, electrically released brake.

Applying spring-set brakes

Whenever practical, a brake should be located on the high-speed shaft of a drive system. In most cases, this is on the electric motor that drives the gearbox and actuator. This permits selecting a brake with the lowest possible torque.

Though spring-set brakes are typically applied to ball screw actuators, they also can be used to prevent backlash in certain Acme screw actuators. For example, a standard 6-pitch, single-thread Acme screw doesn't back drive, but a 6-pitch, 2 or 3-lead Acme screw (mounted vertically) probably will. Back driving can be prevented by a right-angle speed reducer with self-locking gear ratio. However, a spring-set brake generally requires less space and provides more positive control. ■

Stop or hold

Spring-set brakes handle two types of applications: *static holding,* where they are set and released at near-zero speed, and *dynamic braking,* which is used in cycling-type applications.

A static holding brake maintains a load in a fixed position. To select the correct size, simply match the application's holding torque requirement to a brake that has the proper torque rating as listed in the manufacturer's catalog. Multiply the holding torque by a 1.4 service factor, and size the unit with the holding torque rating closest to, but not less than, the resulting figure. This type of brake may also be used to stop small inertia loads under cycling conditions or provide braking under emergency conditions such as a power failure.

A dynamic brake decelerates and stops a load with large inertia and may also be used for holding applications. To size such a brake, use formulas supplied by the manufacturer to determine the dynamic torque required, energy to be absorbed during braking, and frequency of stops. Then select the size brake that meets or exceeds the energy requirements at the correct frequency of stops.