



The Gen2 Unimodule Clutch/ Brake from Warner Electric improves heat dissipation and reduces vibration with an optional enclosure cover kit for quiet operation. Image courtesy of Altra Industrial Motion

## Timely tips

### speed clutch/brake selection

Pick the right clutch or brake for the job and reap the benefits of fast response time, energy efficiency, dynamic torque, and long life. Make an unwise choice and suffer the consequences of slippage and overheating. Learn from our panel of experts how specifying the correct clutch or brake can put the brakes on lost productivity.

#### Clutch and brake basics

How does the choice of a clutch or brake contribute to productivity in today's motion-centric automation environment?

**Edd • Nexen:** Properly sized clutches and brakes save energy and improve machine performance by allowing motors to run continuously, even though the machine itself may start and stop periodically. Motor performance and life are extended in almost any application cycling two to four times per minute, but at six to eight times per minute, a clutch is a necessity.

Pneumatically actuated clutches and brakes are the workhorses of industrial motion control. Simple in design, they are available in a wide variety of sizes and mounting styles, providing fast response, energy efficiency, high dynamic torque, excellent thermal capacity, and long friction-facing life.

**Frank • Ogura:** Although servomotors have taken over many of the traditional clutch-brake applications, electromagnetic clutches and brakes are still an effective option for starting and stopping machinery, especially rotating equipment with a cycle rate of 50 to 250 per minute. Machines that start and stop less frequently typically don't require a clutch or brake; high-speed applications (over 300 cycles per minute), on the other hand, may be better served by servomotors.

One of the main advantages of adding an electromagnetic clutch or brake to a motor is that it lets the motor run continuously, at its highest efficiency, allowing the clutch or brake to accelerate a higher inertia load more quickly. Without a clutch or brake, the motor would have to be accelerated to the speed required, consuming more electricity (since the motor is trying to accelerate the inertia)

and taking longer to reach speed.

High inertia applications requiring fast acceleration may be more effectively handled with a clutch than a servomotor. Advances in materials have also increased clutch and brake life. Ceramic friction materials and longer life bearings let clutches survive for tens of millions of cycles, which can make them more cost effective than servo systems as well.

Although electromagnetic clutch use is falling, electromagnetic spring-applied brake applications are on the rise. In many cases, servomotors are required to have a holding brake in order to protect operators and/or equipment and end products in the event of a power failure. Without electromagnetic power-off brakes, many servomotors would not be able to do their jobs.

**Joel • Warner:** The goal is to optimize the function of the system by maximizing output, minimizing downtime, and maintaining quality, which is based on consistency. This is where the right clutch/brake — with its ability to accurately control motion — adds a lot of productivity benefits. I say the right clutch/brake because it should be sized correctly and it needs to match the application. The technical and productivity objectives of the application need to be clearly defined for the unit to maximize its contribution. People will ask for a clutch/brake for a “typical” application, but really, there is nothing “typical” about any application.

In addition to accuracy of motion control, another chief productivity benefit is in minimizing waste that occurs with downtime caused by e-stops and power failures. Servos aren't fail-safe. Motor systems inherently are not fail-safe — if you lose power, they don't stop on their own. That's where electrically-released

clutch/brakes have an advantage in stopping the drive system, protecting equipment, and minimizing damage and waste. We tend to think of clutch/brakes as only providing a cycling on-off function, but there are many designs that provide a slip or overload function for assembly processes.

### Sizing and specifying tips

**What's your best advice on specifying, sizing, and applying clutches and brakes where productivity is the main goal?**

**Edd • Nexen:** The best location for a clutch or brake is between the motor and gear reducer or on the high-speed shaft. Since speed reducers multiply torque, this mounting allows the use of a smaller unit. Also, the rotational inertia of the load is lessened through the speed reducer, allowing higher cycle rates. Applications of clutches and brakes fall into four general classifications: intermittent, high cycle, high inertia, and continuous slip. Each application requires a different set of considerations:

- **Occasional starts and stops** include applications where the clutch disconnects the motor from the load at cycle rates less than four to five times per minute. Transmitted horsepower and torque are the primary considerations.

- **High cyclic starts and stops** of 60 cycles per minute are considered routine for most clutches and brakes, but much higher rates are achieved if the inertia load is relatively light. Application considerations include torque response time, cycle rate, load inertia, clutch/brake thermal capacity, and speed.

- **High inertia starts and stops** are identified by a requirement to start or stop heavy loads within a specific time period. Start or stop times of one second are typical. Clutch/brake

thermal characteristics and torque are important considerations, as well as speed and system inertia.

- **Continuous slip applications** are typically where material is pulled from a roll. A clutch or brake is connected to the roll-supporting shaft to provide tension in the material. Clutch and brake heat dissipation, line speed, roll and core diameters, and web width are all considerations.

**Frank • Ogura:** Consider the following when sizing clutches and brakes:

**Inertia** — The most important thing when sizing a clutch or brake is to accurately measure the inertia that the clutch or brake would be required to handle. For most applications, system inertia is what determines the torque required from a clutch or brake.

**Speed** — Speeds that are too high or too low can affect clutch performance. Although some users momentarily exceed maximum speed ratings for clutches or brakes, it's important to know why the rating exists. Sometimes it's the bearings that limit maximum speed. Other times, it's because the clutch or brake uses friction discs that can fly apart at high speed. Too slow of a speed can also be a problem because it will not allow a clutch or brake to fully burnish, or mate the surfaces in a clutch or brake. Almost all friction type clutches or brakes require this to achieve their rated torque. Unburnished clutches can have a torque rating of just half their burnished rating.

**Time to speed or time to stop** — Once you know the system inertia as well as the time to accelerate or decelerate a load, you can then determine how much torque is required from the clutch or brake based on the following formula:  $Torque = Inertia \times rpm/308$  (acceleration rate)

**Cycle rate** — Every time a clutch or brake is engaged, energy is absorbed in the way of heat and wear. If you know your cycle rate, you can determine how much wear will occur over a given time period (using a specific formula). You will then know if you will be able to meet your end user's life cycle objectives.

**Operating environment** — Heat is the enemy of all clutches and brakes. An electromagnetic clutch/brake operating at a high ambient temperature can have a degraded flux (the ability to produce a given torque). To avoid that, constant current power supplies are suggested, but if that's not available, the person selecting the clutch or brake needs to factor in (de-rate) the effect of temperature on torque. For pneumatic or hydraulic actuation, a consistent pressure is also required. Contact surfaces in almost all clutches and brakes must remain free of contamination such as water, oil, and grit to avoid slippage.

**Joel • Warner:** The simplest way to size the clutch or brake is by motor speed and horsepower, but that's not necessarily the most productive. It's best to look at the

application and the demands of the clutch/brake output. Most manufacturers provide application assistance either in person or via phone or e-mail. It's wise to share the application details with the manufacturer to let them suggest alternatives that may bring a better choice than the "obvious" solution.

For example, what are you moving? What are the speed and inertia characteristics? Look at the demands of the desired kinematic motion — how quickly it needs to start and stop, and the dynamics of the output. It needs to be big enough to transmit torque, but not so big that it limits cycle rate due to its internal inertia being a dominant part of total system inertia.

On the other hand, if it's too small, the life of the unit can be limited, or it could even cause a catastrophic failure due to inadequate heat dissipation. Also, if it's too small, accuracy can be affected due to the speed of the start/stop cycle, so that could hurt productivity too.

**Bad brakes**

What's the worst that can happen if a clutch or brake is not specified or installed correctly?

**Edd • Nexen:**

Clutch and brake thermal capacity is the most important characteristic and perhaps the least understood. There are three distinct types: heat sink, continuous slip, and peak input rate. Manufacturers' selection programs take these conditions into consideration to select a properly sized unit. Ignoring the thermal characteristics in friction clutches and brakes will result in the destruction of the discs and/or abnormal friction-facing wear.

One of the worst application failures we heard about occurred when a machine builder used a smaller than recommended caliper brake disc on a log chipper. The heat spike into the disc on the first stop resulted in severe heat checking and cracks, rendering the disc unusable and unsafe for subsequent stops.

**Frank • Ogura:** Clutches and brakes are designed to either start or stop rotating equipment. The worst-case scenario for a clutch is that it starts something, but it does not disengage when it's supposed to. For a brake, the worst-case scenario is that it does not stop something when it's supposed to. Whether it's an amusement park ride or a rotating piece of machinery, if a clutch or brake does not operate correctly, people can get severely injured.

For us, typically the worst thing



**Spring applied brakes from Ogura are used to hold the control cables of ActionCam overhead stadium cameras, high definition cameras used in football stadiums and other sporting venues.**

*Image courtesy of Ogura Industrial Corp.*

**This clutch got so hot that the epoxy melted, exposing the coil right before the clutch completely failed. Heat is the enemy of all clutches and brakes.**

*Image courtesy of Ogura Industrial Corp.*



that happens is that a clutch slips until it destroys itself. Basically, there is too much inertia in the system, low voltage, oil contamination, or something else that has caused the clutch to slip. When that happens, the friction surface can get extremely hot. Due to this heat, coil winding insulation breaks down and the clutch shorts out. Sometimes the insulation on the magnet wire holds and the epoxy melts.

**Joel • Warner:** Many years ago, I worked with a company on a cut-off knife where a friction clutch/brake was performing poorly. Given that the application called for a single revolution each cycle, it was a perfect wrap spring clutch/brake application, or so we thought. After five cycles we learned why the friction unit was performing poorly: The knife jammed against a guard, causing an immediate failure of the wrap spring. The friction unit had simply been slipping under load and wearing aggressively as a result. This slip capability of the friction unit had actually been compensating for machine misalignment without the end user being aware of the problem. Once this issue was resolved, the life of the friction unit improved dramatically.

### Clutch clutches, bold brakes

How would you describe the ideal clutch or brake?

**Edd • Nexen:** If we look at the motor-

to-gear reducer interface, the ideal clutch-brake would be an air-engaged combination with a NEMA C or IEC flange. Not only do they use less energy, they also reduce downtime and maintenance, and increase machine life. Key improvements would include making them lighter and more thermally efficient, adding more consumable friction material, and covering them with inexpensive finishes suitable for any environment.

**Frank • Ogura:** The ideal clutch

or brake is one that would be self-powered by an internal power source such as a mini fuel cell or permanent magnet generator. It would have no wires or linkages and it would communicate to a control system via wireless signal. Contact surfaces would have a high coefficient of

friction to transmit high torque over a small area, and it would have unbelievable heat dissipation properties so you could slip the unit for an extended amount of time (basically a magnetized carbon fiber).

**Joel • Warner:** I suppose the perfect clutch/brake would never wear out and it would work just as well in both static and dynamic applications. Applying the brake at zero speed or at full differential speed — when you want both of those capabilities — is a conflict that sometimes makes selection challenging. But one-size-fits-all is not realistic. In a generic sense, the perfect clutch/brake is the one that makes the application work better by whatever metric is important to the end user.



**This spring-engaged caliper brake with brake disk from Nexen Group is useful in a wide range of applications including industrial machinery and conveyors.**

*Image courtesy of Nexen Group Inc.*

## Industry expertise

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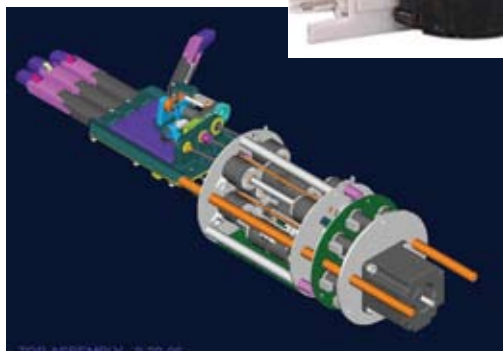
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**This robotic hand uses 18 clutches (inset image) to achieve accurate movement.**

*Image courtesy of Ogura Industrial Corp.*