Choosing electric clutches & brakes to meet thermal capacity needs

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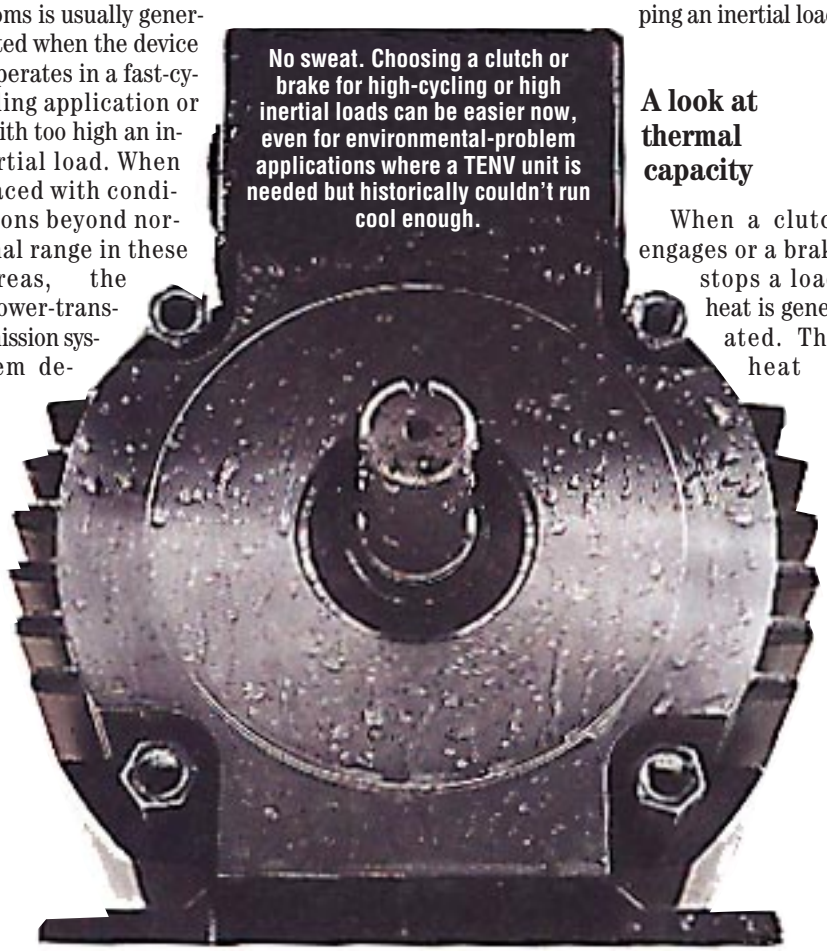
Heat is the enemy of friction clutches, brakes, and clutch-brakes. Most often, the enemy is within. You must keep it neutralized.

Internal rather than external heat in clutches and brakes is the usual culprit, because few applications operate in ambient temperatures high enough to cause fade, slippage, and loss of braking efficiency. The heat that causes these symptoms is usually generated when the device operates in a fast-cycling application or with too high an inertial load. When faced with conditions beyond normal range in these areas, the power-transmission system designer must use extra care in product selection and application. The clutch and brake electromagnets (coils) also contribute to the total heat the product experiences, but it is usually small compared with the heat of friction in starting or stopping an inertial load.



No sweat. Choosing a clutch or brake for high-cycling or high inertial loads can be easier now, even for environmental-problem applications where a TENV unit is needed but historically couldn't run cool enough.

A look at thermal capacity

When a clutch engages or a brake stops a load, heat is generated. This heat is mostly from friction of the working elements as they come into contact and reach a static condition after some slippage. Though the heat is normally absorbed by parts of the clutch or brake, the amount that a unit can dissipate depends on the masses and materials of its parts. *Thermal capacity* is the ability of a given clutch or brake to absorb and dissipate heat without reaching temperatures that would harm its operation.

The amount of heat generated and dissipated by a clutch or brake is a function of load, inertia, speed differential of the load, and number of times the unit must start or stop in a given time. You can calculate thermal capacity from:

$$TC = 1.7(Wk^2)(N/100)^2(F)$$

where:

TC = Thermal capacity, ft-lb/min

Wk^2 = Inertia seen by the clutch or brake, including its own inertia, lb-ft^2

N = Speed differential between friction surfaces at time of engagement, rpm

F = Cycle rate, cycles/min

Be sure the inertia value is that *at the clutch or brake*.

As any variable in this equation increases or decreases, thermal capacity responds likewise. Therefore, operating problems due to excess heat could result

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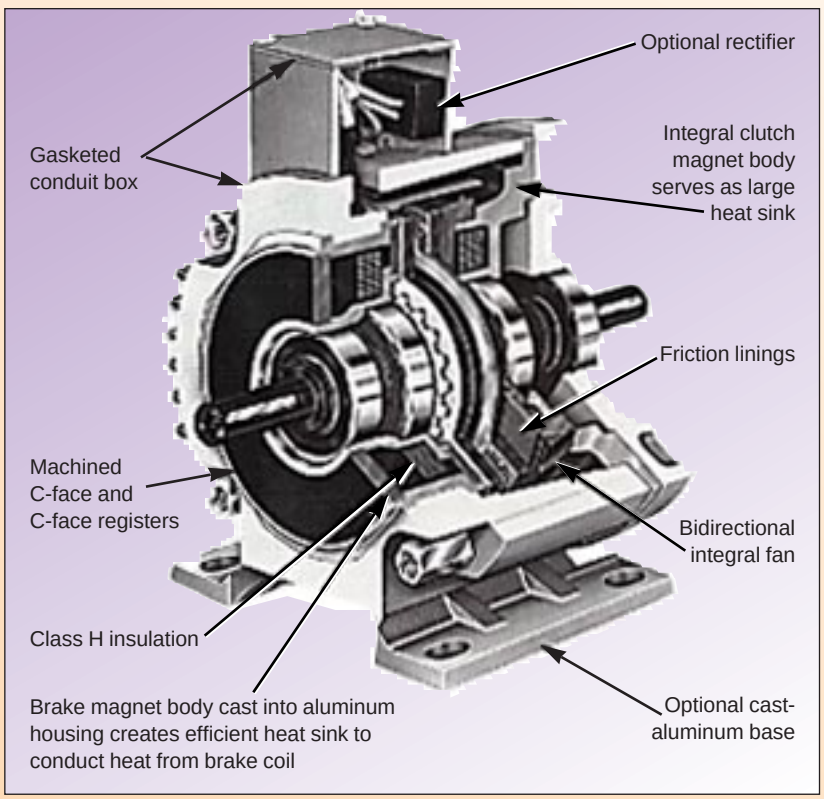
New modular TENV units boost thermal capacity

Stearns Div., Rexnord Corp., expanded its Super-Mod line of modular clutches, brakes, and clutch-brakes with a totally enclosed nonventilated design of high thermal capacity. According to the manufacturer, the units have 96% better thermal capacity than their nearest TENV competitor and need no external fan modification. This allows high cycling. Capacity comparisons are based on the average of 56C and 145TC frame clutch-brake thermal capacity values at 1,800 rpm, with no external fan kit.

The Super-Mod TENV units have cast aluminum housings that meet IP54 (totally enclosed) requirements of the International Electrotechnical Commission (IEC). They keep moisture, water, dirt, and dust from affecting operation. In the new design, major cast components act as a heat sink. A bidirectional fan circulates air within the unit to stabilize internal temperature and prevent hot spots. The system also keeps friction-material wear debris from the unit's environment. The clutch-side magnet body is cast integrally with the endbell, providing a large heat sink. The brake-side magnet body is also integrated into a cast housing for good heat-sinking.



According to the maker, the new units contain 28 to 60% fewer parts than most competitive products, thus enhancing reliability. They are exact drop-ins for most competitive open units. The design has been incorporated into popular Super-Mod sizes.

Each TENV unit has an armature assembly with automatic gap adjustment. It needs no armature adjustment during installation or operation. A conduit box with each unit is gasketed to resist moisture and spray. It can house an optional rectifier for 115 or 230-Vac input. The rectifier connects directly to the ac source, thus avoiding contact arcing and improving switching-component life.

For more about TENV Super-Mod clutch and brake units by Stearns Div., Rexnord Corp., Milwaukee, ***circle 401*** *on the reader service card.*

from extreme inertial load, large speed differential, or high cycle rate, as well as from some combinations of more moderate values of these factors.

Heat can cause increased wear as well as fade, particularly in more severe service and load conditions. Most modular clutches, brakes, and clutch-brakes use finned aluminum housings to dissipate heat. In many modular units with open housings, a fan improves cooling. One manufacturer's line of totally enclosed nonventilated (TENV) modular products includes an internal fan so that axial air movement eliminates hot spots.

Routes to better thermal capacity

If a clutch or brake is too small for the application's torque requirements, it may seem to perform right — until it exceeds its thermal capacity. One sign is a unit that works well for a while; then its stop or actuation time starts increasing.

To select a clutch or brake with enough thermal capacity for your application without over-engineering, you can:

- Select one designed to provide the inherent thermal capacity.
- Add features like external fans to increase heat-dissipation rate somewhat.
- Modify the system design to reduce the demands on the unit.

When a clutch or brake is replaced with a different one, or when the equipment that it serves is used for a different application, its thermal capacity may also be exceeded. The problem may appear to be simple component failure, but it pays to look further if heat buildup seems to be involved. If the unit can't dissipate heat quickly enough, a larger unit may be needed. A solution may require close cooperation among the manufacturers of the equipment and the brake or clutch, as well as the end user.

Especially where environmental conditions require a sealed unit, thermal capacity may be a problem. In food plants and similar applications, clutches and brakes are sealed not only to prevent

damage from washdown and external contaminants, but also to keep internal elements from migrating into the plant environment. Generally, TENV brakes or clutches required for washdown service must be derated because they reach their thermal capacities sooner than open units. This is especially true on food-processing or packaging equipment, which often runs at high cycling rates. Recent design improvements let some new modular TENV units meet or exceed thermal capacity requirements of older open-housed units without derating.

Rapid cycling may cause a clutch or brake to exceed thermal capacity, especially if the design of the unit and the mass of its parts cannot dissipate the generated heat fast enough. There are no exact guidelines for what constitutes a high-cycling application. Also, as already mentioned, a combination of factors can cause thermal capacity problems. However, generally you can regard operations in the range of 40 to 60 cycles/min as higher-than-normal.

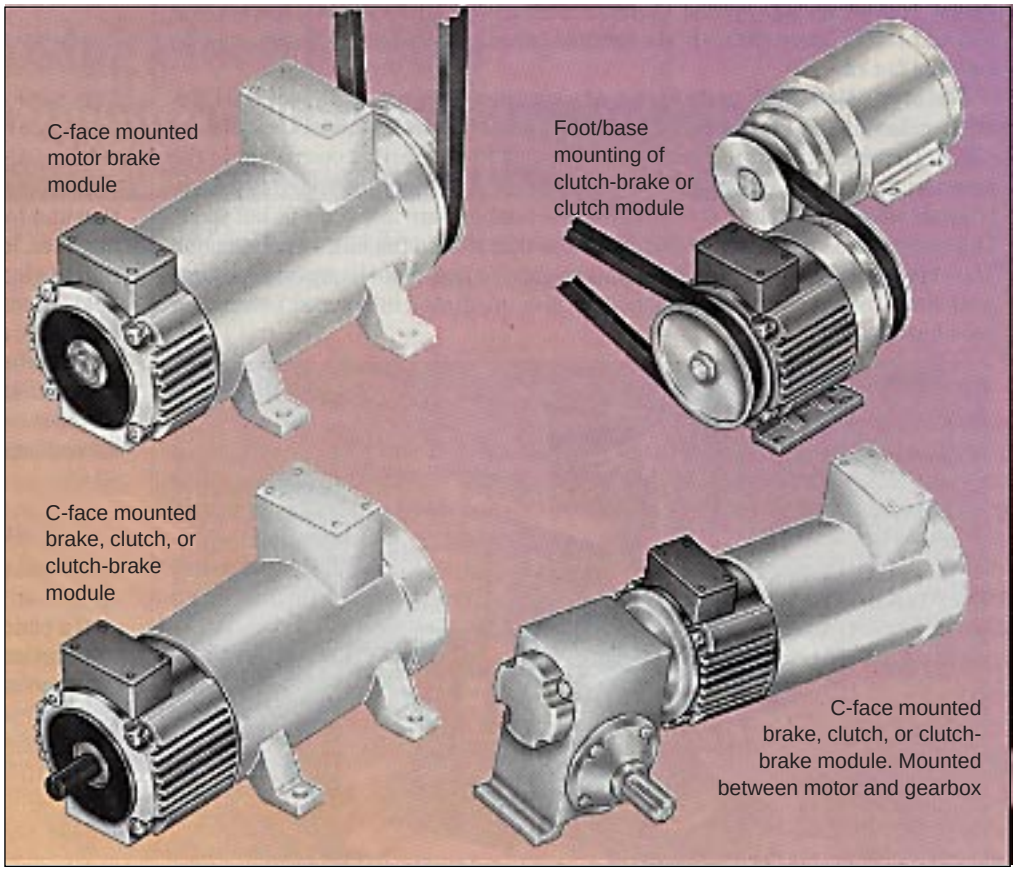


Figure 1 — Some typical arrangements of clutch, brake, or clutch-brake units with respect to drive motor.

Selecting the right unit

When you pick a clutch or brake for a system, your first step is to determine the configuration required. Figure 1 shows a few typical applications to help you recognize some common arrangements.

Modular clutches and brakes are gaining popularity. They adapt easily to many applications and are available quickly in a pre-assembled, factory-aligned form that is easy to install with common tools.

Three basic types of modular units are generally available, though exact offerings may vary among manufacturers. These units can be mounted directly between a C-face motor and a reducer, direct-coupled, or used to connect drive and driven equipment by belt or chain drive. Kits are available for easy field modification, such as converting to a double-shafted unit.

After you select the type of unit, your next step is to determine required size. This assumes that you've determined the size of the motor and other power-transmission components that make up the system's inertial load. Clutch and brake manufacturers generally provide some type of selection chart to simplify the process. Figure 2 shows a typical chart, based on horsepower and speed of the system, which should be the shaft speed at the clutch or brake, not motor speed.

For example, for a clutch to drive a direct-connected shaft powered by a 1-hp, 1,750-rpm motor, Figure 2 would call for the manufacturer's MS-50 unit. If shaft speed at the clutch were at 2:1 reduction it would be 875 rpm, and a higher-torque, MS-100/180 unit would be needed.

The following equation for dynamic torque capability required of a clutch or brake shows the relationship between system horsepower and speed:

$$T = 5{,}252(SF)(HP)/RPM$$

where:

T = Dynamic torque, lb-ft
SF = Service factor
HP = System power, hp
RPM = Speed of clutch or brake, rpm

As speed decreases, required torque

increases. There are other reasons why you should not let speed get too low. Manufacturers recommend keeping application speeds above about 300 rpm, because at lower speed, burnishing or mating wear of the friction faces does not occur and torque capacity may be reduced significantly.

When a clutch or brake must run at very low speed, it may be necessary to oversize it. In most such cases, it is sufficient to use a unit with a static torque rating that is twice the calculated dynamic torque requirement.

About installation

You should be aware of several installation-related situations that may affect system design.

Modular clutches and brakes can serve effectively in most installations and will provide high design flexibility, especially on retrofit projects. Their sizes generally are similar to those of the standard units they replace, but check the dimensions of the new unit to be sure it will fit without interference. Also, if you intend to use existing controls when retrofitting with a modular product, be sure the unit you specify is compatible with power-source voltage.

Although environmental temperatures are seldom high enough for a brake or clutch to exceed thermal capacity, they may compound the problem in a marginal application. Try to avoid cramming a unit into a tight enclosure or placing it next to a heat source if possible, especially when high cycling rates already push the unit toward its thermal capacity.

Overhung loads are another pitfall easily overlooked at first. Especially on clutch applications with a sprocket or sheave, there is a limit to the side force that can be applied without overloading the bearing, deflecting the output shaft, or causing bearing failure.

Though modular units can save considerable downtime because their flexibility permits greater availability, some manufacturers' units come disassembled. Learn whether modular units you specify come assembled. An assembled unit saves time on the plant floor and makes it unnecessary to align components.

Brake or clutch operation depends on the coefficient of friction between the armature and the face of the magnet body. When oil or other material gets between them and changes the coefficient, as much as 75% of torque can be lost.

On equipment that drips or gives off oil vapor, spray water, or similar contaminant, include a shroud or shield to keep the material away, or consider a TENV unit.

Other conditions that can shorten the life of an open brake or clutch include:

- Exposure to gritty dust.
- Poor ventilation.
- Operation wet or in dampness.
- Exposure to oil vapor.
- Exposure to salty air.
- Exposure to fumes.

In applications like these, a TENV unit can pay for itself in added service life. With modern high-capacity designs, fear of inadequate thermal capacity need no longer deter you from considering a TENV clutch or brake. ■

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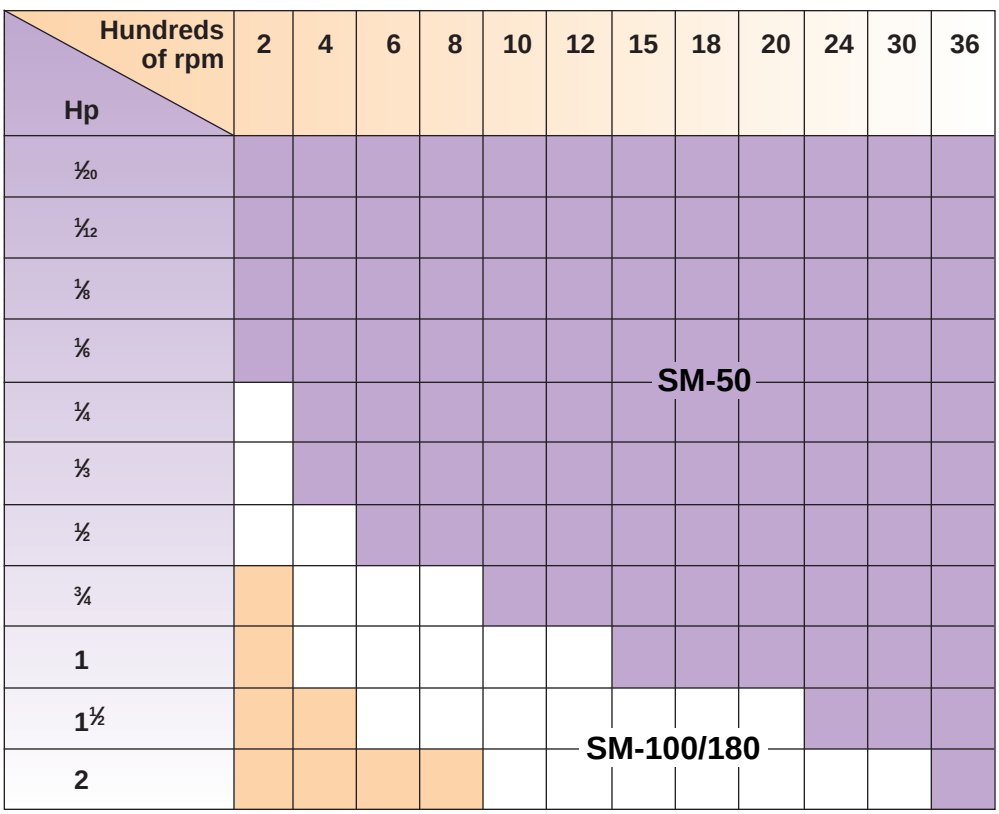

Figure 2 — Typical manufacturer's chart for clutch selection, using horsepower transmitted and shaft speed at the clutch. It is based on a 2.75 service factor.
SM-100/180 is the higher-torque unit. Peach colored area in lower left is no-man's land. Avoid it.