

BASIC MECHANICS

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Two basic mechanical parameters, torque and horsepower, must be completely understood to properly apply AC and DC drives.

Torque

Torque is a force applied that tends to produce rotation. Torque (force) without rotation is called static torque, since no motion is produced.

Torque is measured in lb-in or lb-ft. It is the product of the force in pounds (lb) x the distance in inches (in) or feet (ft) from the center of the point of apparent rotation. Figure 1 shows 120 lb-in (12 inches x 10 lb) or 10 lb-ft torque.

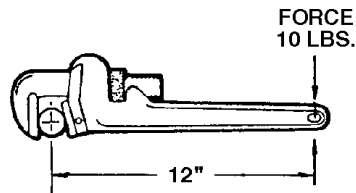


Figure 1
Example of 10 lb-ft Applied Torque

Because most power transmission is based upon rotation elements, torque is important as a measurement of the effort required to produce work.

Horsepower

Horsepower is a measure of the rate at which work is being done. When a force is applied in a manner that produces motion, work can be measured. One horsepower (HP) is defined as the force required to lift 33,000 lbs one foot in one minute.

TORQUE VS. HORSEPOWER

A simple formula exists that relates torque and horsepower to each other. The formula is:

$$\text{Horsepower} = \frac{\text{Torque (lb-ft)} \times \text{Speed (RPM)}}{5250}$$

MATCHING THE DRIVE TO THE MACHINE

The application of an adjustable speed drive to a machine is a mechanical, rather than an electrical problem. When applying the drive, the speed, torque, and horsepower characteristics developed at the motor shaft must be considered. These must meet or exceed the torque and horsepower requirements of the machine being driven.

The torque requirements of a machine fall into three major categories:

- Breakaway torque
- Accelerating torque
- Running torque

Breakaway Torque

Breakaway torque is the torque required to start a machine in motion. It is typically greater than the torque required to maintain motion (running torque). In some applications, breakaway torque is a very important parameter that cannot be neglected. In other applications, such as centrifugal pumps, it is small as compared to running torque.

Accelerating Torque

This is the torque required to bring the machine to operating speed within a given time. With most machines, the load is largely friction and a standard drive rating may have adequate torque for satisfactory acceleration. However, certain machines classified as high inertia with flywheels, bull gears or other large rotating masses may require drive selection based upon the power required to accelerate the load within a given time.

Running Torque

This is the torque required to maintain machine motion after it accelerates to the desired operating speed. Running torque is usually a combination of the torque required to push, pull, compress, stretch or process the material plus the torque required to overcome frictional forces and windage. Running torque may vary as a complex function of operating speed. It is very important to understand the torque requirements of the application before attempting to apply a drive. In general, most applications will fall into one of the following categories:

- A. Constant torque
- B. Constant horsepower
- C. Variable torque

A. Constant Torque—About 90% of all general industrial machines (other than pumps) are constant torque systems. The machine torque requirement is independent of its speed. If the machine speed is doubled, its horsepower requirement doubles. Constant torque is illustrated in Figure 7 (page 10).

B. Constant Horsepower—For machines with constant horsepower loads, the power demand is independent of speed and torque varies inversely with speed. This type is most often found in the machine tool industry and with center driven winders. When drilling, shaping, milling or turning metal, the loads all tend toward constant horsepower. At low speed there is high torque; at high speed, light torque. A drive must be selected for its highest torque requirement at the lowest speed. Constant horsepower is illustrated in Figure 8 (page 10).

C. Variable Torque—This type of load is commonly found on centrifugal pump drives and in most fan or blower applications. The torque and horsepower both vary with speed. Variable torque is illustrated in Figure 9 (page 10).