Variable Torque Applications

In most processes, the load varies with speed as described using one of the following terms: variable torque loads, constant torque loads, constant horsepower loads, and impact loads. When applying a control and motor to a process, it is important to determine how the load is related with speed.

Variable torque loads are good candidates to apply Adjustable Frequency Drives (AFDs) for energy savings. Typical examples of such loads are centrifugal pumps, centrifugal fans, centrifugal blowers, and centrifugal compressors. Savings can reach as high as 60% in some applications. For example, heating and cooling systems can have an AFD installed to control fan speed. Instead of operating the motor at a fixed speed and adjusting the airflow by means of dampers and vanes, the motor speed can be adjusted to control airflow. Lowering motor speed saves significant energy, and it can be done automatically when the AFD is interfaced with the heating and cooling system control.

Centrifugal pumps are also likely candidates for AFDs and ultimately energy savings. Like fans, centrifugal pumps boast variable torque load, and HP requirements drop off exponentially as speed is reduced. The Wisconsin Center for Demand-Side Research indicates that savings can reach 25% for fans. Savings for blowers and central refrigeration systems can reach 35%, and savings for feed water pumps can be as high as 50%. An AFD also has the benefit of increasing the motor’s connected power factor to near unity.

Load Application Considerations

With a variable torque load, the loading is a function of the speed. Specifically, as the speed is increased or decreased, the torque required of the load will change with the square of the speed.

**Breakaway Torque** - A pump or fan normally requires less than 50% of full load torque to start initially from rest.

**Accelerating Time** - A variable torque load normally has a low inertia. Also, the accelerating torque required is low and the drive and motor usually have sufficient capacity to meet the time requirements for most pump and fan applications.

**Decelerating Time** - Regenerative braking is normally not required when stopping pumps and fans.

**Squared Torque Variation**

A variable torque load having a squared relationship means that the torque varies at a rate proportional to the square of the speed and horsepower varies as the cube of the speed, reaching 100% load torque and horsepower at a defined speed. (See Figure 1)

Because of the very low torque requirements at low speed, low speed operation is not normally an important consideration with variable torque applications. Motor load decreases, which offsets the affects of reduced cooling. During running, the highest motor load, and therefore operating temperature, occurs at the highest operating speed because the load increases with speed for variable torque loads. The horsepower requirement of the load continues to increase above base speed yet the motor torque may be decreasing if control voltage is being held constant. For operation above...
motor base speed, the motor’s capability must exceed the load requirements.

Although the load inertia for some variable torque applications such as large fans can be high, rapid acceleration is typically not required. As a result, the load can usually be accelerated without exceeding motor rated torque.

**Linear Torque Variation**
A variable torque load having a linear relationship means that the torque varies linearly with speed and horsepower varies as the square of the speed, reaching 100% load torque and horsepower at a defined speed. (See Figure 2)