

TECH NOTES

Application Guidelines to Keep You Better Informed

MOTORS & DRIVES

Overspeeds

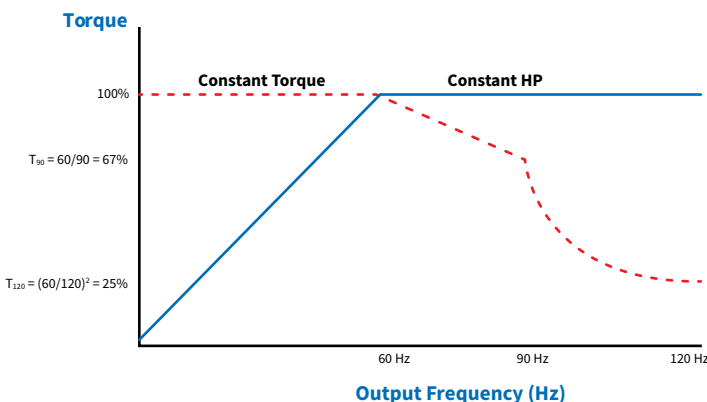
Using Overspeed

Adjustable speed drives (ASDs) are used most often for two common purposes: Process Control and Energy Savings. However, a third reason that should not be overlooked is their ability to provide an unlimited number of starts and stops without harmful effects to the motor.

Process Control refers to having infinite speed control over the motor to either slow it down for greater control or to speed it up for increased production. Energy Savings can be realized when applied to variable torque loads such as centrifugal fans and pumps, whose torque is dependent upon speed as per the theory described in the affinity laws (torque is proportional to the square of the speed, 90% speed = $(0.90)^2 = 84\%$ torque).

In overspeed situations, the available torque from a motor/drive system can become a big issue. The ASD can only output as much voltage as is available at the input. Maximum voltage is usually set to 60 Hz. As the frequency increases above 60 Hz, there is no more available voltage to maintain constant torque. As the speed increases above 60 Hz, torque must decrease if HP is to remain constant, as per the laws of the following equation:

$$HP = \left\{ \frac{\text{torque} \times \text{speed}}{5250} \right\}$$



A 3 HP, 575 V drive was used to run a 3 HP, TEFC, 4-pole motor at 60, 90, 120, and 150 Hz. At rated motor current, the following maximum continuous torques were developed:

PREDICTED VS. ACTUAL TORQUE

Hz	Actual (% Full-Load Torque)	Predicted (% Full-Load Torque)
60	182	100
90	97	67
120	56	50
150	36	40

- The torque required to move the motor's fan increases as the square of the speed change.
- Above 60 Hz, the motor's breakdown (maximum) torque decreases as the square of the speed change.
- The motor's inductive reactance (or impedance) increases at the same rate the frequency increases. As the impedance increases, the current decreases (because more voltage is not available), thereby decreasing the available torque.

For the above motor test, at 150 Hz it appears that the breakdown torque (which decreases as the square of speed increase) has "crossed" over the full-load torque and is now the limiting factor for torque development within the motor.



Recommendations

- On applications requiring output frequencies up to 90 Hz, derate the motor's rated full-load torque by the ratio of base frequency to maximum operating frequency.
- On applications requiring output frequencies greater than 90 Hz, derate the motor's full-load torque by the square of the ratio of base frequency to maximum operating frequency.
- Check with the motor manufacturer concerning overspeed operation. Rotor balance and bearing life are of concern when over-speeding a motor. A quality-built 1800 RPM and 1200 RPM motor up to 200 HP should be able to handle a 2x overspeed without concern. NEMA MG1 does provide overspeed guidelines for motor manufacturers to meet and not all motor and ASD manufacturers are the same.



OVERSPEEDING A 230 V-RATED MOTOR USING A 460 V OR 575 V-RATED DRIVE

There are some applications such as high speed planers, conveyors, and compressor packages that are well-suited to over-speeding of a motor. The benefit of using, for example, a lower RPM motor such as a 900 RPM, 1200 RPM, or 1800 RPM motor on a high-speed application is that a lower-speed motor produces more torque for the same HP rated drive, and there may also be size and weight benefits because in some cases, the motor frame is smaller and lighter, which can be of concern for the equipment to which it is mounted.

Most drive/motor packages, however, have a small twist to the overspeed theory we've discussed. A 230 V-rated motor running on 460 V or 575 V-rated drives will not have a torque reduction because the drives are programmed to apply 460 V at 120 Hz. This allows the package to provide constant torque right up to 120 Hz, allowing for compact, low weight, and economical motor/drive packages.

However, the downside is that if high torque transients are required at the higher operating frequency (i.e. at 120 Hz), the lower HP/RPM motor will likely not produce as much peak torque as the higher HP/RPM motor would. For the right application, this could provide some benefits.