TOSHIBA

Informative Application Guidelines, with respect to *Motors & Drives* to keep you better INFORMED.

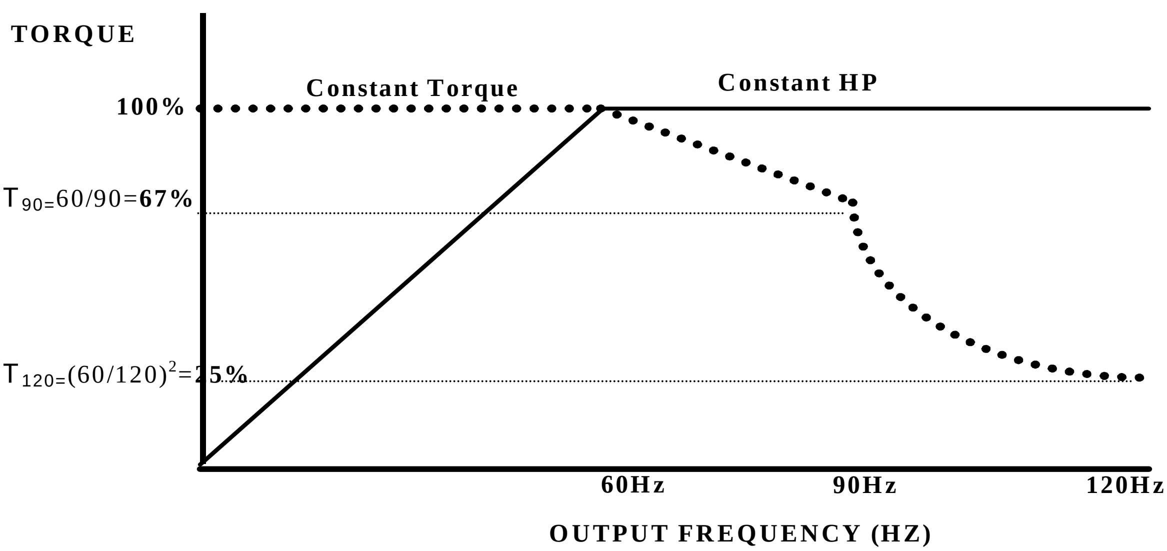
APPLICATION GUIDELINE #10

(Overspeeds)

…….Brought to you by your Motor & Drive Specialists

Variable frequency Drives (VFD's) are used 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 VFD can only output as much voltage as is available at the input, maximum voltage usually is set to 60Hz, thus as the frequency increases above 60Hz, there is no more available voltage to maintain constant Torque. As the speed increases above 60Hz, torque must decrease if Hp is to remain constant, as per the laws of the following equation: $Hp=\left\{\frac{\text{torque x speed}}{5250}\right\}$.



A 3 HP 575 volt 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:

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

The 'Predicted' versus 'Actual' torque estimates worked out to be a linear inverse relationship up to and including 120Hz (2x overspeed), however we recommend above 1.5x overspeed that the torque estimates be reduced by the square, as shown in the graph above.

Note: As motor RPM increases:

- The torque required to overcome bearing friction increases at the same rate.
- 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 (impedance) increases at the same rate the frequency increases. As the impedance increases, the current decreases (because more voltage isn't 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.

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 1800RPM and 1200RPM motor up to 200Hp should be able to handle a 2x overspeed without concern. NEMA MG1 does provide overspeed guidelines for motor manufacturers to meet.

ASIDE: Overspeeding a 230V rated motor using a 460V or 575V rated Drive

There are some applications such as 'high speed planers' 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 900RPM, 1200RPM, or 1800RPM motor on a high speed application, is that a lower speed motor produces more torque for the same HP rated drive, and there are also size and weight benefits because in some cases the motor frame is smaller and lighter which can be of concern at times for the equipment it is being mounted on to.

Most drive/motor packages provided for the above however have a small twist than the overspeed theory we've discussed above, the twist is that 230V rated motor running on 460V or 575V rated drives will not have a torque reduction because the drives are programmed to apply 460V at 120Hz. This allows the package to provide constant torque right up to 120Hz. This provides for compact, low weight, and economical drive/motor packages, however the downside is that if high torque transients are required at the higher operating frequency (ie: at 120Hz), the lower HP/RPM motor will likely not produce as much peak torque as the higher HP/RPM motor would. For the right application though, this could provide some good benefits.

Please contact us for more information on this topic.