APPLICATION EDGE
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TMEIC
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APPLYING VARIABLE FREQUENCY DRIVES TO EXISTING MOTOR APPLICATIONS

What do we need to worry about if we apply a new Medium Voltage VFD to our existing MV motor?

All Induction and Synchronous Motors:

Reduced cooling at reduced speed

Most motors running across the line depend on an internal, shaft-driven fan for cooling. When the motor is run on a VFD, the motor shaft speed (i.e. motor speed) will be decreased and this will cause decreased cooling from the shaft-driven fan. If the load is a standard variable torque load like a fan or pump (load on the motor decreases exponentially with speed) there may not be a need for additional cooling.

However, if the existing motor is running an application that has constant torque (such as a reciprocating compressor or pump, mill, extruder, etc.) then the load will stay on the motor as the speed is reduced, and the motor will overheat. For this situation, it may be necessary to add an external blower (or auxiliary fan) to provide sufficient cooling for the motor to operate below rated speed. This extra blower ensures that enough air moves over the windings to keep them cool when the internal fan is insufficient. You can see this illustrated in figure 1. The constant torque load goes well above the motor cooling capability, thus the external blower would be required.

If the motor was built with temperature sensors (RTDs) in its windings, then these can be used to monitor the heating and ensure that the VFD and the reduced speed operation are not causing the motor insulation to be damaged by overheating.

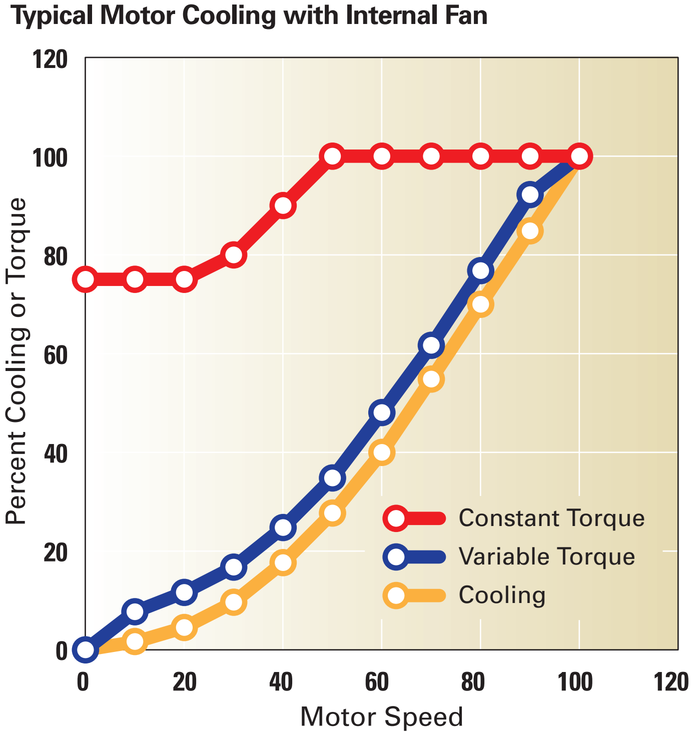

Figure 1. Motor cooling vs speed

Increased heating due to VFD harmonics

All VFDs will produce some additional level of heating in motors. However, many of today's MV VFDs have very harmonically clean output wave forms. If you are using one of these types of VFDs, there will likely be no derating required for the motor; but be sure to verify this with your VFD supplier. Below is a comparison of the voltage that the motor terminals see on both a typical TMEIC VFD (left side) and direct on line (right side).

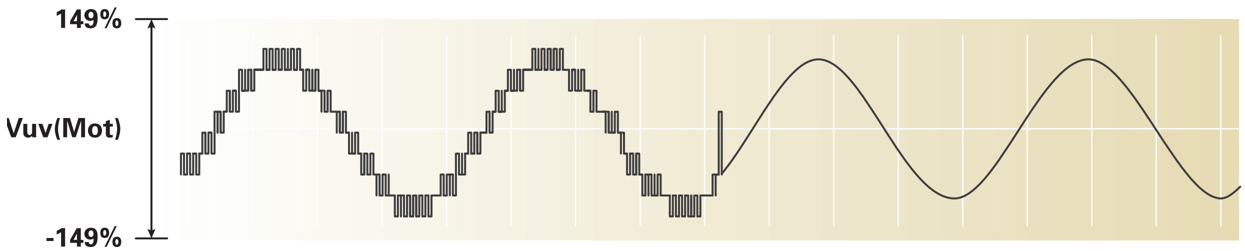

Figure 2. VFD vs Utility wave form at motor terminals

Motor Voltage

There are VFD output voltages available on the market to match almost any existing motor voltage. However, for very high-voltage (13800 V) motors, there are very few, if any, VFDs that have a direct 13800 V output. For these cases it is often necessary to use a step-up transformer on the output of the VFD to match the motor voltage. It should be noted that this transformer will represent approximately one percent more loss in the VFD system, and this should be evaluated during the analysis stage for cost effectiveness.

Motor Frequency

There are VFD's with output frequencies to match any motor rated frequency. Since the VFD is controlling the motor speed (and frequency), this can allow a motor rated for one power system (like 60 Hz) to be run effectively, and at full rating, on a 50 Hz power system.

Motor Speed

Motor bearings may be dependent on speed for lubrication. Antifriction bearings are well-suited for variable speed operation but sleeve bearings may need special attention to ensure they will be lubricated correctly as the motor is run at lower speeds. This would probably be more critical for very low-speed operations like creeping, positioning, warm-up or coast-down.

High-speed induction motors (motors with 2 magnetic poles designed to run at 3600 rpm at 60 Hz) are known to have a shaft critical resonance in the range of 2200 to 2800 rpm. For motors running constant speed across the line, this resonance is not important as the motor never operates there. However, since a VFD is capable of running a motor at any speed within its allowable speed range, care needs to be taken to avoid running the motor at a speed near its resonance. Most MV VFDs have the capability to "skip" or not run at certain frequencies so that these resonance areas are avoided.

Extra Considerations for Synchronous Motors:

Field Exciter

For existing synchronous motors to be applied to VFD operation, the synchronous motor must have its DC field available at zero speed to develop starting and accelerating torque.

- Two types of synchronous motor field exciter designs that are suitable for starting and operating on a VFD use either DC slip rings, or an AC brushless type exciter. These designs can energize the field at standstill, during acceleration, and while running.
- One type of synchronous motor using a DC brushless type exciter cannot develop field at zero speed because the exciter generator must spin up to a high speed in order to develop field current.

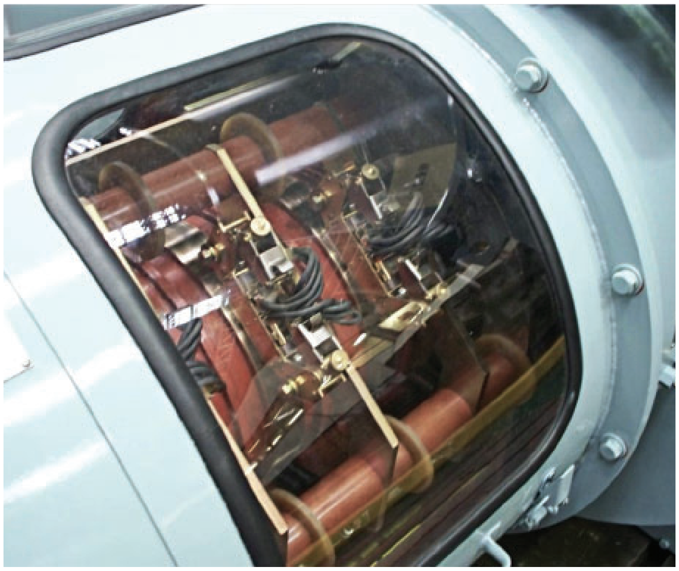

Figure 3. Typical slip rings in a motor

Power Factor Control

It is important to note that the synchronous motor can be used to deliver reactive power benefits to the power system. However, if this motor is operated on a VFD, the utility power line sees the reactive power level set by the drive incoming converter, not the motor. Therefore, if the synchronous motor is being used for power factor correction to the plant, this will not be a suitable application to power this motor from a VFD.

Positive Aspects of VFD-driven Motors:

Production Related Issues

1. Recalling that a VFD-started motor has no limits on the number of allowable starts per hour, if anything in the process stops the motor, it can be restarted immediately. For a line-started motor, it might be necessary to wait for the protection relays to determine if it is safe to restart the affected large motor, or risk motor damage.

2. While on the VFD, the output can be varied to match the needs of the downstream process.

Energy Related Issues

1. If the process requires operation at less than 100% output (flow, speed, etc.), the energy difference between max and running points provides the opportunity to save energy.

2. A typical VFD system operates at a total overall efficiency of around 97%. For those times when the process requires operation at 100% output, synchronizing to the line provides a direct connection of the motor to the utility, saving the 3% losses represented by the VFD. During the time when the motor is synchronized, the VFD is left in standby mode to allow the motor to be captured and smoothly connected to the VFD.

Maintenance Related Issues

1. Synchronized starting reduces motor stress and could extend motor life and reduce maintenance.

2. Operating the industrial process at less than top speed using a VFD decreases the mechanical wear on the driven components. This is particularly obvious on such applications as conveyors, crushers, etc. This, of course, is contingent on the production needs at the time being met at a reduced speed.

Conclusion

This article presented the potential concerns when applying a VFD to an existing motor, and suggested ways to mitigate them. It is extremely important to work closely with your VFD supplier in these scenarios, to ensure that the motor can be converted to operate on a VFD, and that no issues are overlooked. TMEIC application engineers are highly experienced in this type of retrofit.

For specifications not mentioned here, contact TMEIC

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