PQTN
Power Quality Testing Network

APPLICATION

Industrial Processes
Motor Bearings
Current Discharge

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Preventing Premature Failure of Bearings in Motors Driven by PWM ASDs

Application

Advances in semiconductors and power electronics technologies have made adjustable-speed drives (ASDs) with pulse-width modulation (PWM) technology a popular choice for many motor-driven processes. Originally, ASDs with PWM inverters had switching rates between 1 and 8 kHz. To eliminate the audible motor noise caused by such low switching frequencies, manufacturers developed ASDs with switching frequencies as high as 20 kHz. The faster switching frequencies did reduce motor noise, but they also created a side effect: excessive motor-shaft voltage and current that can discharge across the motor bearings.

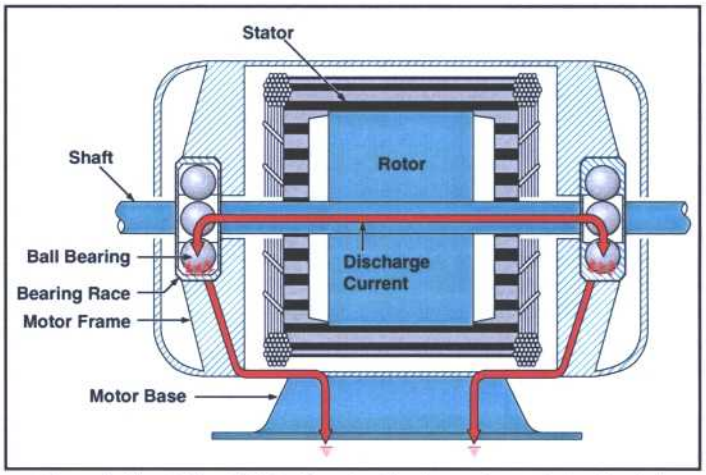

Figure 1. The Paths of Motor-Bearing Discharge Currents in a Typical Three-Phase Motor Driven by a PWM ASD

ASDs that use insulated-gate bi-polar transistors (IGBTs) as high-frequency switches are most likely to cause bearing-discharge current. The high switching frequency and fast rise times of an IGBT inverter output can cause induced voltage in the rotor to be capacitively coupled to the motor shaft. As shown in Figure 1, this shaft voltage can exceed the dielectric strength of the lubricant in the shaft bearings. The resulting current flows from the shaft, through the bearing lubricant, and to the grounded motor frame, pitting—or *fluting*—the bearing races. The resulting high rolling resistance leads to premature failure of the shaft bearings. This PQTN Application provides ASD users with some pragmatic insights into the nature of the problem caused by bearing discharge currents and suggests preventive or corrective actions to avoid the problem.

What To Look For

Audible motor noise and vibration are usually the first obvious symptoms of premature bearing failure. Because excessive noise and vibration can be symptoms of other motor problems, maintenance personnel frequently misdiagnose problems caused by fluting. Usually, the current arcing across the bearings will first damage the smaller idle bearing opposite the end of the shaft connected to the motor load. Idle-bearing failure can occur as soon as six months after the motor has been installed.

Discharge current may also damage the bearings of other equipment connected to the motor shaft, such as direct-connected tachometers and gear boxes. In many cases, discharge current will damage the tachometer bearings instead of the motor bearings because the smaller tachometer bearings offer the path of least resistance. Damaged tachometer bearings can cause the tachometer to vibrate, resulting in an erratic signal from the tachometer.

A shaft voltage as low as six volts can cause arcing through the bearing lubricant, depending upon the type of bearing lubricant and the clearing between the race and the ball bearings. Excessive shaft voltage can be verified in two ways. One way is to measure the shaft-to-ground voltage, which requires a specialized shaft-monitoring device. If motor bearings have already failed, then inspect the bearing races for fluting. If the bearing races look similar to those in Figure 2, and the ASD driving the motor is a PWM-type with a switching frequency above 10 kHz, then most likely the shaft voltage is excessive.

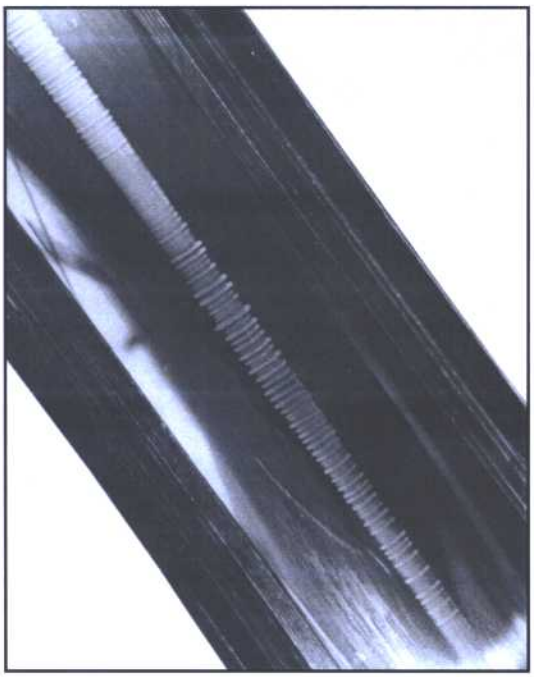

Figure 2. Fluting of the Bearing Race Caused by Current Discharged through the Bearing Lubricant

Quick Check List

- ❑ Look for signs of premature bearing failure such as audible motor noise, vibration, and localized heating.
- ❑ Look for fluting in the races of damaged bearings from motors and other shaft-connected equipment such as tachometers, pumps, fans, and gear boxes.
- ❑ Reduce shaft voltage by installing a shaft grounding system.
- ❑ Stop current from discharging through motor bearings by replacing existing motor bearings with insulated bearings or decreasing the switching frequency of the ASD that drives the motor.
- ❑ Purchase new motors with bearings guaranteed against premature bearing failure.

HOW TO PREVENT PREMATURE BEARING FAILURES

Install a Shaft Grounding System Minimizing the magnitude of the shaft voltage reduces the chance of electrical arcing through bearing lubricant. Grounding the motor shaft with a system of brushes creates a low-impedance path to ground for otherwise damaging discharge currents. A number of brush systems are commercially available. Soft carbon brushes are usually not suitable because they may create a nonconductive film that prevents electrical contact between the brushes and shaft. Brushes made of special materials—such as brass and stainless steel—do not create this film. Also, a sealed grounding system is recommended for a clean-room environment, which may be contaminated by airborne particles from a standard grounding-brush system. During every routine maintenance, ensure that the brushes are in electrical contact with the shaft, regardless of the type of grounding system you select.

Install Insulated Motor Bearings Although insulated motor bearings stop the flow of discharge current through the motor bearings, they do not prevent damage to the bearings of other shaft-connected equipment, such as tachometers and fans. Also, the voltage on the shaft of a motor with insulated bearings and without shaft-connected equipment may pose a risk of a mild shock to anyone who touches the rotating shaft.

Decrease the ASD Switching Frequency The switching frequency of most PWM ASDs can be set by the operator. By decreasing the switching frequency of an existing ASD, you can prevent the premature failure of motor bearings. Although shaft voltages will be present at lower switching frequencies, industry experience to date indicates that problems caused by discharge current begin mostly when the ASD switching frequency is greater than 10 kHz. Therefore, if shaft grounding systems or insulated bearings are impractical options, then avoid using switching frequencies above 10 kHz. If a higher switching frequency must be used, then purchase motors with warranties against bearing failure caused by discharge current.

BENEFITS

- Prolong motor bearing life and reduce maintenance costs by reducing shaft voltage.
- Enhance effectiveness of ASD applications by eliminating problems caused by discharge currents.

WHERE TO FIND HELP

- Motor and Drive Vendors
- Industrial Power Consultant
- Your Local Utility

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For More Information, contact HECO's Power Quality Engineers at (808) 543-4756

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