The Barn Raiser

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VFD Caused Induction Motor Bearing Failures – Part 2

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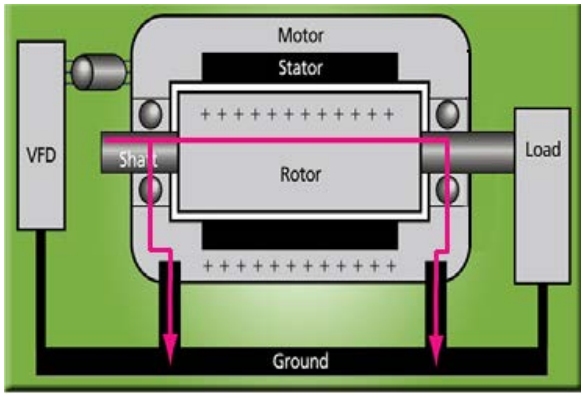

Protection

Few current technologies designed to protect AC motor bearings from shaft current damage meet all the criteria of effectiveness, low cost, and application versatility. The most efficient form of protection may consist of the use of more than one of the following technologies.

1. *Faraday shield:* Placing grounded conductive material, such as copper foil tape or copper paint, in-between the rotor and the stator results in a *Faraday shield* protected motor, also known as an Electrostatic Shield Induction Motor (ESIM). The shield prevents the high frequency VFD currents from being induced onto the shaft by effectively blocking it with a frame grounded capacitive barrier between the stator and rotor.

2. *Insulated bearings:* Insulating material, usually a nonconductive resin or ceramic layer, isolates the bearings and prevents shaft current from discharging through them to the frame. This arrangement forces current to seek another path to ground, such as through an attached pump or tachometer or even the load. Due to the high cost of insulating the bearing journals, this solution is generally limited to larger-sized NEMA motors. Sometimes, high frequency VFD-induced currents actually pass through the insulating layer and damage bearings anyway.

3. *Ceramic bearings:* The use of nonconductive ceramic balls prevents the discharge of shaft current through this type of bearing. As with other isolation measures, shaft current will seek an alternate path to ground. This technology is very costly, and in most cases motors with ceramic bearings must be special ordered and have long lead times. Moreover, because ceramic bearings and steel bearings differ in compressive strength, ceramic bearings often must be resized to handle mechanical static and dynamic loading.

4. *Conductive grease:* In theory, because this grease contains conductive particles, it would provide a lower-impedance path through the bearing and bleed off shaft current through the bearing without the damaging discharge. Unfortunately, the conductive particles in these lubricants increase mechanical wear to the bearing, rendering the lubricants ineffective and often causing premature failures. This method has been widely abandoned as a viable solution to bearing currents.

5. *Grounding brush:* A metal brush contacting the motor shaft is a more practical and economical way to provide a low impedance path to ground, especially for larger NEMA frame motors. However, these brushes are subject to wear because of the mechanical contact with the shaft. There are some new third party grounding kits that are available to install as part of the whole system. Early testing and patent applications of such kits claim to eliminate shaft voltage from the system altogether.

6. *Shielded cable:* Grounding can be significantly improved by installing shielded cable with an extremely low impedance path between the VFD and the motor. This shielded cable limits the effects of Electromagnetic interference from external sources, as well as provides a lower impedance path for high frequency capacitively coupled currents to ground.

"The Barn" built in the 1930's to house Welsh ponies, serves as Mid-South's offices.

VFD Motor Bearing Failures - Continued

7. *Shaft grounding ring:* This approach uses a ring of specially engineered conductive microfibers to redirect shaft current and provide a reliable, very low impedance path from shaft to frame, bypassing the motor bearings entirely. The ring uses ionization principles to boost the electron transfer rate and promote extremely efficient discharge of the high-frequency shaft currents induced by VFDs. With hundreds of thousands of discharge points, the shaft grounding ring channels route currents around the AC motor bearings and protect them from electrical damage.

Testing

Currently, there are two common non-destructive methods used in the industry to detect bearing currents and bearing current damage: vibration analysis, and shaft-to-ground voltage and current analysis. The voltage and current analysis is to be preformed in accordance with a method detailed in IEEE-112-2004, "IEEE Standard Test Procedure for Polyphase Induction Motors and Generators," paragraph 8.3, Shaft Current and Voltage. While both can be implemented to either confirm or deny bearing current suspicions, owners are better served by incorporating these methods to establish a baseline and monitor trends. This can provide early detection of possible problems. It can also verify whether or not any installed protection methods are effective.

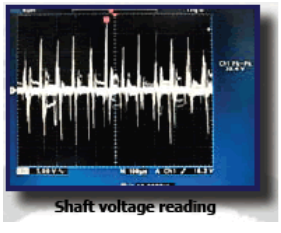

Figure 2A

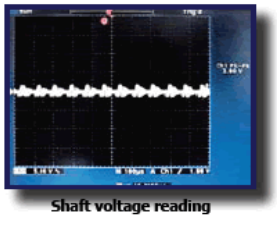

Figure 2B

Figure 2A represents voltage measured at the shaft with no protection, and Figure 2B represents voltage measured at the shaft with protection. Notice that there is still a shaft voltage reading with protection. All motors have some level of voltage measured on the shaft; a determination must be made at what level is cause for alarm (i.e. cause enough current to discharge through the bearings to the frame) There are many variables that can affect the measured data, for example, bearing lubrication, measurement equipment and method, running speed, distance between rotor and stator, etc…

Conclusion

Damaging bearing currents can occur in any VFD controlled motor application, and will eventually cause motor bearing failure. The motor bearings are damaged when accumulated shaft current discharges through the bearing causing *Fluting.* When and where bearing currents will become a problem is still unpredictable, although things such as high frequency PWM and inadequate grounding can increase the risk and accelerate damage.

If you have frequent motor failures and they are driven by VFDs, then bearing currents could be a problem at your installation. You can protect your equipment by using one of several methods, either independently or in combination. The most popular and successful methods include shaft grounding devices, insulated bearings, and Faraday shields.

Determining whether or not protection is warranted and determining the appropriate methods of protection is a shared responsibility based on cost analysis and risk assessment. Educating ourselves and each other about the cause, effect and protection of bearing currents is the best line of defense, and why we are publishing this article to our friends.

Adapted from:

IEEE-112-2004, "IEEE Standard Test Procedure for Polyphase Induction Motors and Generators,"
http://www.nasatech.com
http://ecmweb.com
http://www.greenheck.com
http://www.emisymposium.org/13th.papers/docs/EML087.pdf
www.est-aegis.com
http://www.egr.msu.edu/~jurkovi4/bearingcurrents.pdf

Merry Christmas & A Happy New Year

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