+1.888-416-9513 main
+1.419.281.4087 fax

740 E 9th Street
Ashland, OH 44805
United States
www.pentair.com

WHITE PAPER

Premium Efficient Shaft Grounding Rings VFD Operation

Introduction

When a motor is operated on a variable frequency drive, unexpected voltage can be induced on the rotor and shaft. A number of solutions have been employed in order to prevent early bearing failure in motors operated on drives.

Define The Problem

It is an established fact that some motors operating on variable frequency drives experience early failures (less than the expected mean time between failure), even when the motor is designed per NEMA MG1 part 31 standards, which describes motors for use with variable frequency drives. Pre-mature failures can occur in as little as 500 hours, which may be less than 1% of the motor's expected bearing life. Although the windings may be designed to perform with non-sinusoidal waveforms presented by VFD's, early failure may result from bearing damage.

When a motor is operated on a variable frequency drive, unexpected voltage can be induced on the rotor and shaft. The voltage seeks a path to ground and a current path may become established through the shaft bearings. The voltage build-up on the rotor shaft can occur due to the high dV/dT switching rate of the drive in addition to capacitive coupling between the rotor and stator. This often happens when switching rates exceed 5 KHz. The capacitive coupling causes further voltage build- up on the rotor and shaft. Normally, no current flows between the rotor shaft and frame ground until the voltage level exceeds the insulating characteristic of the oil or grease film that the bearing balls or rollers ride upon. Once this lubrication layer is breached, current can flow from the rotor shaft, through the bearing to frame ground. It is the flow of current through the bearings that cause them to pit, gall or fret leading to premature failure.

Solutions

A number of solutions have been employed in order to prevent early bearing failure in motors operated on drives. Insulating the bearings from the motor frame has shown some improvement in bearing life. However, most electrical insulating materials also act as capacitive components. The insulator may pass electrical current, just as a capacitor can, which defeats the purpose of the bearing insulator.

Non-metallic bearings have also been used as a method of counteracting shaft current and subsequent failures. Most non-metallic bearings are manufactured from ceramic compounds. These ceramic materials do not exhibit the same material characteristics of steel bearings. Axial and radial loads must be considered when sizing and selecting non-metallic bearings. Same size bearings may not yield similar LB10 life.

Early prevention methods attempted to incorporate a "Faraday" shield between the rotor and stator to disrupt the capacitive coupling effect. Actually producing a commercial motor with an internal Faraday shield has not been found to be practical with current manufacturing methods

Grounding brushes and rings have been found to be very effective devices for limiting or eliminating bearing failures due to shaft currents. Brushes and rings act as a shunt and direct any present voltages from the shaft directly to frame ground.

Shaft brush shunts must be designed so that the conducting material has a long wear life and stays in contact with the end of the shaft. Depending upon its placement, the materials of construction must be selected so that any worn material does not contaminate the inside of the motor and bearings.

Hydromatic has selected the Shaft Grounding Ring (SGR) method as a means of eliminating/minimizing shaft currents in their motors used in conjunction with variable speed drives. Unlike a shaft brush which typically contacts the non-drive end of the motor shaft, the SGR is an annular ring that slides over the non-drive end of the shaft. SGR's require less pressure on the shaft than brushes and therefore have a greater life expectancy. The Hydromatic supplied SGR is located outside of the bearing journal which separates the bearing and SGR.

In all cases, good grounding practices must be followed in order to minimize shaft current effects on motor bearings.

Oil-Filled Motors

Hydromatic's oil-filled motor is less susceptible to shaft voltage induced bearing failures since the bearings are constantly bathed in oil. There is less chance for the insulating film to break down and provide a ground path through the bearings.

Conclusions

Motors operated on variable frequency drives are susceptible to early bearing failure. Hydromatic's HPE series of premium efficient submersible motors is supplied with windings suitable for use with VFD's per NEMA MG1 part 31. Hydromatic's optional Shaft Grounding Rings and oil-filled motors are designed to minimize or eliminate early bearing failures when their premium efficient motor is used in conjunction with a VFD. For the lowest cost of ownership – including maintenance and operating costs, consider Hydromatic VFD rated Premium Efficient Motors with Shaft Grounding Rings.

For more information, contact your authorized Hydromatic distributor, or Kevin Clemons, Senior System Applications Engineer, Pentair Flow Technologies LLC at 419.281.9200 or kevin.clemons@pentair.com.