Waterproof Step Motors Make Waves in Industry

Because of the preponderance of water and solvents, motion control components are often exposed to the risk of corrosion and failure. Waterproof motors are a key part of the solution to water-induced motor failure problems.

Today's waterproof motors are specifically designed to survive a minimum of 30 feet under the sea, a general industrial standard for the "waterproof" designation. These are not retrofitted standard step motors, but are truly waterproof motors, which operate very well above the waterline, too -- in a wide variety of industrial and marine settings. The motors have been fitted with redundant shaft seals, O rings, hermetic cable feedthrough, pressure equalization and other waterproofing features. Together, these design features allow a step motor to answer a design engineer's need for a motor that will not fail after even prolonged exposure to, or submersion in, most liquids.

Why don't ordinary step motors meet this need? Although these motors are the mainstays of industry and the laboratory, and provide reliable and accurate positioning for minimal cost, their design includes several weaknesses with respect to moisture. First, the coils of the standard stepper are wound with magnet wire, a solid copper wire that is coated with an enamel or varnish. While the coating process is good, it is not perfect, and the varnish always has some small pin holes in it.

When this magnet wire is wound into a coil, it is unlikely that any two pin holes will line up and "short out." Ordinarily, the spacing of the wires provided by the layers of exterior enamel prevent conduction from one pin hole to the next. However, if even a little water gets between the wires, it will promote conduction from pin hole to pin hole. In this situation, the current from the power supply will quickly destroy the motor windings. Although quality insulation and impregnation can prevent this problem, they add greatly to product cost.

Step motors are constructed of magnetic iron, and corrode very easily when subjected to moisture. To optimize torque, the gap between the rotating and non-rotating teeth of the motor is held to about .002 in. When the motor is operating, these teeth get hot, and the temperature is typically high enough to turn any water in the motor into steam. Steam is corrosive, such that the magnetic iron in the teeth rusts faster than usual.

Once the rust fills the .002 in. air gap, rotor and stator teeth begin to rub. This robs useful torque from the motor and breaks the iron oxide loose. If the rust is dry, it forms an abrasive powder, if it is wet, it forms an abrasive slurry. This oxide slurry gets into the motor bearings, and being abrasive, the bearing wear accelerates. As the bearings wear, the centering of the rotor becomes less accurate, causing the rotor to wobble as it turns and eventually hit the stator.

The combination of oxide build-up on the magnetic teeth and the loss of bearing accuracy can cause a standard step motor to fail in a period as short as two weeks. While it is possible to substitute non-corrosive metals for the magnetic iron, the metal will be more expensive, it will cost more to machine, and motor performance will be significantly degraded.

Attempts could be made to prevent moisture from entering a motor. However, standard step motors are not designed to facilitate seals. They are designed to be low in cost. As a result, proper sealing of the motor would require a complete re-design of motor parts, with an increase in manufacturing cost.

A proper design approach for motors exposed to moisture incorporates shaft seals, O rings, cable feedthrough, and pressure equalization mentioned earlier with other features that combine to create a "real" waterproof motor. For instance, while standard motor housings are made of painted cold rolled steel and/or aluminum, a waterproof motor's exterior is commonly made of stainless steel to resist corrosion.

A waterproof motor is designed to accommodate O-ring seals, allowing the watertight sealing that is not practical in a standard motor. Further, the wiring that leads to the motor coils in a waterproof motor requires a hermetically-sealed feed-through device to prevent water from wicking into the motor via the cable conductors.

Other seals are required. For instance, a threaded pipe plug at the rear of the motor is designed to allow the housing to be sealed after the motor connections have been made; this plug is also fitted with an O-ring seal. The motor shaft itself is provided with redundant shaft seals. Additional life-extending features include double insulation, coated laminations, and fittings for pressurization.

Some of the above features may be found on a standard motor, but it is the combination of all of these features together that produces a waterproof motor with a superior service life.

The existence of the new waterproof motors, and the design innovations they represent, do not simply extend motor life in moisture-filled applications -- in many cases, the applications would not be possible without this type of motor.

Recent Waterproof Step Motor Applications:

Naval/military
Aquaculture
Undersea exploration
Robotic submarines
Salvage robots
Undersea mining
Oil exploration
Sonar arrays
Communications
Automated undersea lights and cameras
Automated hydrophone arrays
Wave power generation
Flood control systems
Floating seafood factories
Hydrofoil air cushion controls
Antenna and gun pointing systems

Food processing

Cleaning, chopping, dispensing, packaging, vacuum sealing, inspecting and labeling

Corn dog machines

Automated ice cream cup fillers

Meat slicers

Pineapple coring machines

Juice box filling and sealing machines

Drug manufacturing: Pill pack sealing, packing, labeling, gene splicing microscope stages, media plate filling

Medical supply manufacturing: Artificial blood vessels, rubber gloves, sterile bandages

Automated machine tools: Mills, lathes, screw machines, grinding applications, cut-off tools

Automated inspection: Water jets and ultrasound in water tanks, inspection of nuclear reactor components

Antenna pointing systems for satellite tracking stations

Upper atmosphere wind study equipment

Railroad track grinding equipment

Pipeline welding and pipeline x-ray equipment.

Paper manufacturing

Chemical manufacturing

Film processing

Printing

Water jet cutting

Toxic clean-up equipment

This article is written and provided by Rick Halstead, President of Empire Magnetics, Inc. Empire Magnetics provides quality motor products designed to perform in environments and applications where ordinary motors are unsuitable. For more information about Empire Magnetics, please visit their website at www.empiremagnetics.com.