Putting Some Predictability into Wind Turbine Maintenance

By Glenn Dorsey

A wind turbine typically lasts 20 years. But most wind turbine warranties cover only the first two to five years of a wind turbine's life. As these systems age, not all facility owners are necessarily prepared to take on the task of maintaining their wind turbines. In some instances, there is a shortage of technicians to do the maintenance work. And even when a facility has the technicians it needs to perform routine repairs, unscheduled maintenance can put a noticeable dent in a facility owner's bottom line.

One way that wind farm owners, engineers, technicians and makers of wind turbines can mitigate the risk of unscheduled repairs is to consider components that require less maintenance and even tell you when they're going to fail. If that sounds like a far-fetched notion, it's not.

A Small, But Critical Component

Fiber brush slip rings are one such product. Although they are a relatively small part of the overall cost and design of a wind turbine, slip rings are critical to operation. Found inside the wind turbine's nacelle, slip rings are commonly used to provide electrical signals and energy for blade pitch power and control. Slip rings transfer electrical power and signals across a rotary interface.

Here's how slip rings work: sliding contacts transmit electrical signals and energy across the rotating interface in a slip ring assembly. A brush, or wiper, slides on a rotating ring and maintains continual electrical contact during rotation. This means metal-to-metal contact is required between the stationary brush and the rotating ring for error-free electrical transmission.

A fiber brush slip ring can offer wind turbine owners a minimum of 100 million revolutions of operational life with no maintenance, which means a technician might have to switch out the slip ring once during the turbine's 20 years of life. But all slip rings are not created equal. In fact, it is important to understand the design and construction of slip ring assemblies to evaluate their maintenance requirements.

A Market Breakdown

Roughly ten percent of slip rings on wind turbines are fiber brush slip rings, which require little to no maintenance. The majority, or about 60%, of slip rings are made of composite metal brushes, which are typically metal and graphite sintered together into a conductive block. Even if these composite metal brush slip rings offer up to 75 million revolutions of operational life, as their makers claim, they need frequent maintenance. The remaining 30% of slip rings found on wind turbines employ single wire noble metal brushes (frequently made from gold). Both composite metal brush slip rings and single wiper brush slip rings demand maintenance above and beyond what fiber brush slip rings need.

Here's why. Composite brushes are designed to wear preferentially to avoid ring wear and it takes a sufficient length of brush to squeeze out the maximum time between brush replacements. There are three challenges with this material in high-power and/or high-reliability slip ring applications:

1) The wear debris that is generated during operation is conductive, abrasive, powdery and takes periodic cleaning;
2) This brush material is sensitive to moisture and can wear unevenly if the relative humidity is less than 15% or more than 85%; and
3) When used for signal-level circuits, these composite brushes take up a lot of space.

The advantages of the single wiper metal brush slip ring design over the composite brush design are primarily less wear debris and more capacity for signal circuits. But there are disadvantages to this contact system, too:

1) Limited current-carrying ability because of the relatively small size of the single wiper; and
2) Most gold-on-gold contacts, for example, need lubrication, and it is difficult to consistently provide a sufficient amount.

The market is starting to see slip ring designs that use graphite/metal brushes for power circuits mixed with gold monofilament brushes for signal circuits. This "hybridization" can produce acceptable results in applications requiring a low number of revolutions on the slip ring assembly. But mixing graphite/metal and gold-on-gold brushes in one assembly can be unreliable in wind turbines. The graphite/metal debris can contaminate the gold signal ring contacts and produce abrasive slurry, especially in the presence of contact lubricants leading to premature failure on the signal circuits.

The fiber brush design bundles multiple metal filaments into a compact multi-fiber "brush." Typically, these fibers are noble metal, materials comparable to the single wire design, and the ring on which the brush operates is noble metal plated. The use of noble metals prevents oxides and coatings from forming on the contacts and ensures very light contact forces. The light contact reduces the wear rate, so the brushes produce negligible wear debris. And the multiple metal fibers provide very good conductivity and very high current density, so engineers can use the fiber brush for both power and signal.

Making the Switch

Composite metal brush slip rings and single wiper gold slip rings are fairly simple to replace with fiber brush slip rings. But for some wind turbine owners, the hesitancy to replace their existing slip ring technology with fiber brush slip rings simply stems from a perception that trying something new entails risk. For those who have closely examined fiber brush slip ring technology, they find they have eliminated risk and maintenance in opting for a component that requires little if any looking after.

For example, fiber brush contacts are much less sensitive to the environment inside the wind turbine's nacelle than other slip ring contact technologies. The seals to protect these fiber brush slip rings meet various standards including IP65, which pertains to protecting equipment against water as well as dust. And since the fiber brush contacts require no lubrication, they are very tolerant to both low and high temperatures. Fiber brush designs have been qualified in temperatures as low as –55° C and as high as + 80° C. But fiber brushes can also operate between 0% and 100% relative humidity (RH). In contrast, composite brushes require humidity between 15% and 85% to operate reliably.

Many people associated with the wind energy business know about the reliability problems of numerous components. And there is now a broader awareness of what causes components to break down during operation. But slip ring technology, including the fiber brush slip ring, is still a piece of technology that's under the radar of many wind farm owners in spite of advances in design and performance.

Initially, makers of large wind turbines used composite brushes, which generated metal/graphite debris from contacts. To combat the metal dust and debris created by these composite contacts, manufacturers turned to gold contacts. But fiber brush slip rings improve upon these designs. In many cases, though, wind farm owners are still replacing old-style slip rings up to once a year with the same technology. They are buying the same original factory equipment. And this approach continues a cycle of unnecessary maintenance and replacement.

Alternatively, replacing slip rings with the maintenance-free fiber brush technology could be performed in as little as 30 minutes if carried out as part of a wind turbine's regularly scheduled maintenance call. And for those who own, design, operate and maintain wind turbines, fiber brush technology means one less unscheduled maintenance issue for a wind farm's uptime.

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