Don't Let Encoders Stop Your Wind Turbine Generator!

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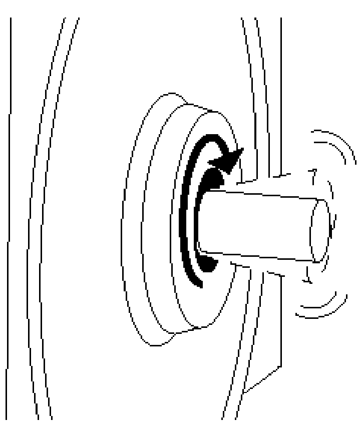
INTRODUCTION

Most wind turbine generators require accurate and reliable encoder feedback to properly control the generator and to synchronize the output with the line frequency. However, the encoders used in these applications often fail due to the rough environmental conditions and high vibration in the wind turbine application. This paper describes methods and innovations to increase wind turbine generator encoder reliability.

Finding the Problem:
It is relatively easy to spot an encoder failure in a wind turbine generator—it typically causes a controller "trip" which causes the turbine to go into a shutdown mode. But determining the root cause of the problem can be more difficult.

Generator encoder failures fall into two rough groups: bearing failures, and internal electronic failures. Bearing failures are common in generator encoders and are fairly easy to detect once the encoder is removed from the generator (the encoder turns roughly or not at all). There are (4) common causes of encoder bearing failure:

1. Wobbling stub shafts. Typically the generator shaft is too large to mount a conventional encoder, so a small shaft is added to the back of the main shaft. If the stub shaft has any wobbling movement (runout), it will destroy the bearings of a hollow shaft encoder (or break the coupling of a solid shaft encoder).



2. Rough installation. If a hollow shaft encoder is pounded on the shaft even by hand, this damages the encoder bearings. Failure is not immediate, but the encoder is doomed.

3. Incorrect tether mounting for hollow shaft models. The tether should be at 90 degrees to the shaft and parallel to the front surface of the encoder. Tethers at other angles put pressure on the encoder bearings as they try to "tilt" the encoder body.

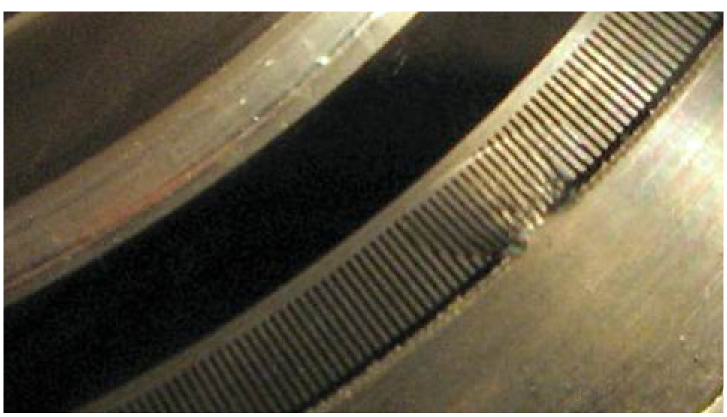
4. Undersize encoder bearings. Many encoders use tiny bearings (<100lb rating), and this makes them extremely vulnerable to items (1-3).

To eliminate bearing failures there are two basic approaches:

A1: Take more care with the encoder installation, and use a heavier duty encoder. If the stub shaft is reasonably straight: TIR (total indicated runout) <0.002" [0.05mm], then a heavy duty encoder with large bearings will withstand more errors in mounting, less-than-ideal tethers, and much more. Examples include the Nidec-Avtron HS45 and AV45 encoders. They feature bearings 4-10X larger than a typical generator encoder. Even heavy duty encoders can't be hammered onto the shaft however, and they do have bearings that wear out over time.

A2: Eliminate encoder bearings altogether. Modular magnetic encoders use the bearings of the generator itself to support the rotor disk, and the stator is bolted to the generator end-plate. This type of encoder requires reasonably precise centering around the shaft ~0.030" [1.27mm] but has virtually no moving, wearing parts. Examples include the Nidec-Avtron AV115, AV125, and AV850 encoders. These encoders have an additional advantage; they can directly fit on large bore shafts, so the need for a small add-on shaft can be eliminated. The encoder can be directly mounted on the generator shaft. The stator housings are extremely durable and can withstand direct hammering or impacts! These types of encoders are in use today in over 10,000 wind turbines worldwide and have a tremendous record of reliability (over 4,500,000 hour MTBF!)

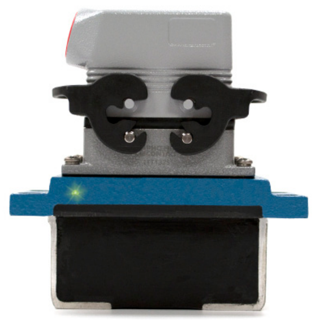
Internal Encoder Electronic Failures are extremely difficult to troubleshoot. The encoder may be intermittent or may fail suddenly without warning. Most common generator encoders use an optical sensing system which has several common causes of failure:



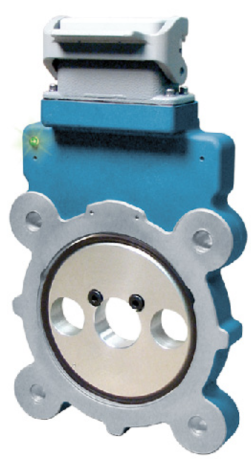
1. Rough handling or installation. The glass disks and precision optics used in optical encoders were designed for precise machine tools, not banging up 80m towers on a tool belt while climbing a ladder or vibrating continuously on the back of a huge generator. The encoder sensor is less than 0.005" from the spinning disk. Heavy vibration or shock causes the disk to contact the sensor causing a head crash much like a computer hard disk failure.

2. Seal failure caused by temperature cycling. Traditional encoder seals were designed to keep out machine tool oil at 70°F, not to withstand the fierce temperature cycles of a wind turbine. Typical running temperatures are >140°F, and nighttime temperatures plunge easily to -20 or -40°F. As the temperature changes, the air inside the encoder expands and contracts at a different rate than the outside air. This constant pressure cycling always causes encoder seals to fail. Moist air enters the encoder then condenses, causing either the precision optics to malfunction or the electronics to short. Often these failures are maddeningly intermittent.

To solve internal electronic failures:



A1: Use a heavier duty magnetic encoder. Magnetic encoders don't have the precision optics that are vulnerable to rough handling. Heavy duty models pot the electronics into a solid block of plastic, and protect them with a cast aluminum housing. With Wide-Gap technology, the sensor can be very far from the spinning rotor so even continuous vibration and heavy shocks can't cause the magnetic sensor to strike the rotor.



A2: Use fully potted encoder models with superior seals. If the electronics are fully potted into a brick of plastic, even if contamination enters the encoder, it can't harm the electronics. By using a superior seal, abrasive particles can be kept out that could otherwise harm encoder bearings. Again, no-bearing models are even better, because they don't have bearings to protect.

A3: Add predictive encoder diagnostics. Predictive diagnostics can be added to the encoder to indicate when the signal is less-than-ideal. Both local indication for the service technician (LED), and remote indication for the site manager should be provided. If an encoder reaches its signal limits, it issues a warning before it causes a shutdown of the turbine. The encoder can be accessed and serviced during scheduled downtime.

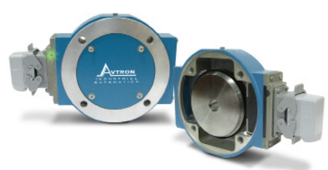
In summary, the key causes of encoder failure in wind turbine generators can be overcome through design, selection, and, installation improvements.

Appendix:
Nidec-Avtron Encoder Models for Wind Turbine Generators:

AV45 (Shafted, Coupled) Heavy Duty Magnetic Encoder
Features:
Heavy duty bearings
Superior Seals
Magnetic Sensor Technology
Local and Remote Predictive Diagnostics

HS45 (Hollow Shaft) Heavy Duty Magnetic Encoder
Features:
Heavy duty bearings
Superior Seals
Magnetic Sensor Technology
Local and Remote Predictive Diagnostics

AV115 (Modular Bearingless) Heavy Duty Magnetic Encoder
Features:
No Bearings or Seals Required!
Magnetic Sensor Technology
Local and Remote Predictive Diagnostics
Fits shafts up to 3 3/16” [85mm]



AV850 (Modular Bearingless) Heavy Duty Magnetic Encoder
Features:
No Bearings or Seals Required!
Magnetic Sensor Technology
Local and Remote Predictive Diagnostics
Fits shafts up to 4 1/2” [115mm]

AV125 (Modular Bearingless) Heavy Duty Magnetic Encoder
Features:
No Bearings or Seals Required!
Magnetic Sensor Technology
Local and Remote Predictive Diagnostics
Fits shafts up to 7 7/8” [200mm]

For more information about this article or encoders & tachometers in general, contact:

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