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A World of Lubrication Understanding®

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Today's Topics:

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Going Green - Wind Turbines & Lubricant Testing

Wind energy continues to grow in importance in the US and around the world. With about 380 billion kilowatt-hours produced in the US in 2021, it accounted for about 9.2% of electricity generated nationally, according to the US Energy Information Administration (EIA). Wind generation made up almost 7% of all electricity generated around the world in 2020 with US wind generation accounting for about 19% of the total. The EIA predicts continued growth in wind energy over the next 30 years, and this ongoing growth is visible in Savant Labs' neighborhood. In 2020, Michigan power company Consumer's Energy brought 150 megawatt of wind generation online in Gratiot County, just a few miles south of Savant's location in Midland, Michigan, and another 200-megawatt project is underway there this year.

Serving the Lubricant Industry

To best serve the lubricants industry, Savant Labs are providing wind turbine lubricant testing to support wind generation locally, nationally, and internationally. With the high forces, high rotational speeds, and variable conditions a wind turbine experiences in operation, lubrication is critical. Figure 1 shows many of the moving parts that require lubrication in a typical wind turbine.

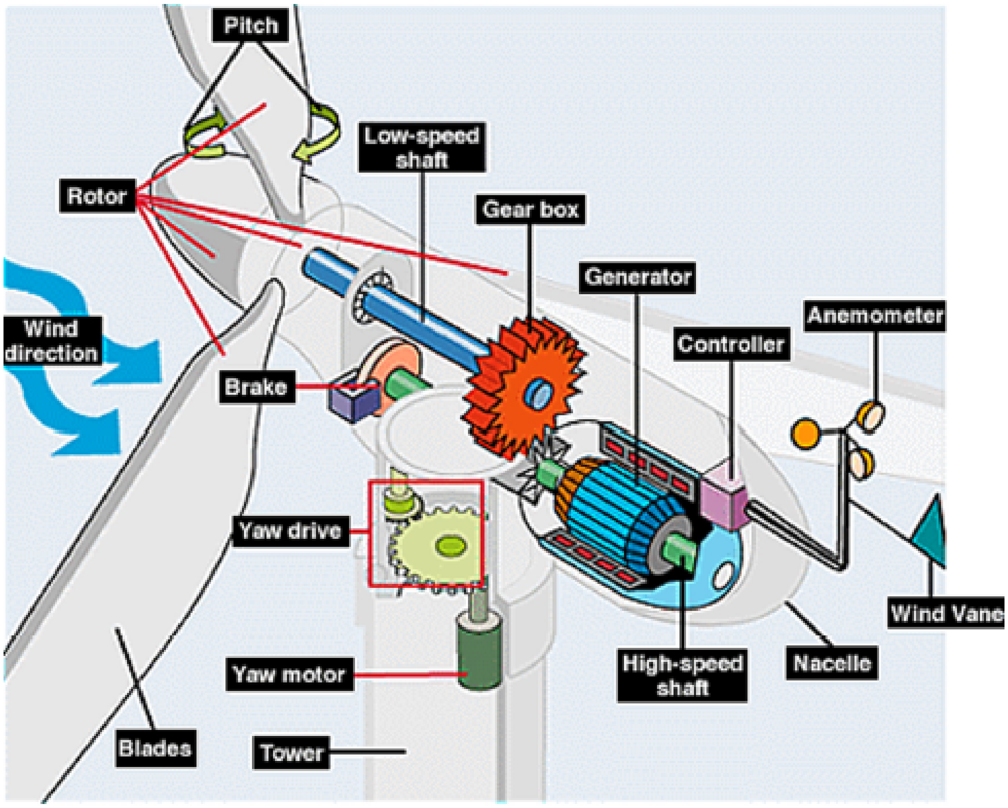

Figure 1. Diagram of wind turbine components Source: National Renewable Energy Laboratory, U.S. Department of Energy (public domain)

Wear of Key Components

The gearbox is generally considered the most important and vulnerable lubricated component. The US National Renewable Energy Laboratory (NREL) completed a study in 2011 that showed that gearbox damage was the leading cause of downtime and the most expensive repair for the wind turbines in use (Sheng et. al., 2011). The gears are susceptible to surface wear such as micro-pitting and scuffing. Lubricants with antiwear and extreme pressure additives can protect against scuffing and other surface wear. Furthermore, the use of the fluid with the proper viscosity provides an adequate film thickness to prevent contact between the gear teeth. Micropitting can also be exacerbated as an oil oxidizes in service and contains higher levels of acidic compounds.

Along with gearbox damage, damage to the main shaft and bearings or the generator account for the majority of all downtime. Excellent antiwear properties and proper viscosity across the operating temperature range are typical requirements to maintain proper bearing function, for both oils and greases used in wind turbine bearing applications. Furthermore, there is some implication that certain additives may encourage hydrogen absorption in the bearings, contributing to the much-researched but still poorly understood phenomenon of white etching cracks (Aikin, 2020). These cracks are a major concern because they can lead to very premature bearing failures.

Materials Compatibility

In addition to these specific wear problems, wind turbine fluids must exhibit good materials compatibility. For instance, they must not damage seals, which can cause fluid leakage. Compatibility with paints and coatings used in the wind turbine is also important. As with all lubricants, wind turbine fluids need to resist foaming, minimize corrosion, and exhibit good oxidation stability, which extends the drain interval. Finally, the lubricant needs to have good pumpability across the operating temperature range, which can include cold ambient temperatures in higher latitudes. Many of the same tests that are used to validate automotive oils or industrial gear oils can be used to evaluate whether a lubricant is well suited to a wind turbine application. Some possible tests Savant Labs offer and what they tell about a fluid are listed in Table 1.

	Test Name	Industry Designation	Lubricant Function Tested
Usually In-Service Monitoring	Kinematic viscosity	ASTM D445	Film thickness and minimization of internal friction, lubricant aging
	Acid number	ASTM D664 ASTM D974	Lubricant aging, possibility of corrosion due to acidic components
	Water content	ASTM D6304	Fluid degradation by absorption of water, possibility of corrosion due to water exposure
	Elemental analysis	ASTM D4951 ASTM D5185 ASTM D2622	Changes in levels of additives, indication and identification of wear materials or contaminants; D2622 is for sulfur only
	FTIR oxidation	ASTM D7414	Lubricant degradation due to oxidation products and depletion of antioxidants
	Fluid cleanliness	ISO 4406	Particle contamination
	Insolubles	ASTM D893	Contamination with varnish products
Usually New Fluids	Foam	ASTM D892	Tendency of the fluid to form and maintain foam, mixing of incompatible fluids (when applied to in-service fluids)
	Low temperature properties	ASTM D97 ASTM D2500 ASTM D5133	Low-temperature flow and pumpability: pour point, cloud point, and Scanning Brookfield
	Elastomer compatibility	ASTM D7216	Seal material condition after exposure to fluid

Table 1. Some tests available through Savant Labs that may be helpful in evaluating wind turbine fluids.

In-Service Fluid Monitoring

In addition to determining whether fluids are generally appropriate for wind turbine applications, the wind generation industry makes extensive use of in-service fluid monitoring. Many installations use in-line sensors to monitor overall cleanliness or conductivity, which can indicate some level of information about wear and oil degradation. Even more important, the standard practice in the industry is to sample the gearbox oil about every six months during scheduled maintenance and send it to a testing lab, such as Savant Labs, for analysis. The tests conducted can vary, but tend to include fluid cleanliness, viscosity, acid number, water content, elemental analysis, analysis of oxidation, and ferrography. Together, these tests can identify the beginning of a wear problem and can even be used to identify root causes before the gearbox sees catastrophic failure due to wear damage. Tests that indicate the level of insoluble particles due to varnishing or foam can also indicate problems from incompatible fluids being used to top off or fill after a drain. Savant Labs offer all of these tests.

The effectiveness of fluid testing was demonstrated in a research project conducted by NREL. The wind turbine gearbox under test installed for operation at a wind farm saw some temperature excursions above 90 °C, as well as two fluid loss events. Researchers were able to determine based on the laboratory analysis of the fluid that the gear teeth were wearing abnormally after just 300 hours in service. This was later verified by visual inspection after the field-testing component of the project was complete. The researchers were able to retain the gearbox for the remaining stage of testing because they removed it prior to catastrophic damage (Sheng et. al., 2011).

Another benefit of periodic fluid testing is the ability to assess whether a fluid drain interval can be extended in a particular case. A five-megawatt wind turbine can require 700 gallons of lubricant, and costly synthetic fluids are preferred in the industry. Typically, oil change intervals are scheduled for from 9 to 16 months. In a project conducted by OELCHECK and Fraenhofer Institute for Wind Energy Systems (IWES), a gearbox in a wind turbine installed in the field using a polyalphaolefin (PAO) was monitored for almost four calendar years. Only slight degradation was seen in the fluid as a small reduction of additive content and increase in oxidation products. The fluid could continue to be used without replacement, despite the long interval (Coronado and Wenske, 2018).

Savant Provides Fluid Testing Programs

The cost of implementing a fluid testing plan that coincides with regularly scheduled maintenance on a wind turbine installation is minimal compared with the costs of waiting until a failure becomes catastrophic to find it or changing wind turbine fluids more often than necessary. With Savant Labs as the laboratory partner in a fluid testing program, a wind turbine operator would have years of testing expertise, rapid test turnaround, continuous communication, and a quality guarantee statement. Savant Labs are an enthusiastic and capable participants in supporting the growth of wind energy generation.

Because Quality Matters

Savant is positioned to offer some of the most precise data found in the industry to date. Regular instrument calibration and maintenance to meticulous reference values and control chart monitoring is part of the quality regimen. In addition, all test results undergo a stringent quality review process, data is delivered on time and reported via email in a logical format designed for easy interpretation.

References

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TEOST Turbo® Testing Method Now Published as ASTM D8447

Determination of Turbo Charger Deposits by Thermo-Oxidation Engine Oil Simulation Test Method

ASTM D8447 was recently approved and published by the ASTM International. Developed and made exclusively by our sister company, Tannas Co., the TEOST Turbo® instrument is designed to predict the elevated temperature deposit forming tendencies of an engine oil subject to the added oxidizing stress of a turbocharger.

As engine designs have evolved over the years, particularly turbochargers, the need for an additional modification to the TEOST® platform became evident. ASTM D6335, the original turbocharger bench test, also known as TEOST® 33C, was developed in the early 1990s to screen engine oils by their tendency to form coking deposits within the elevated temperature zones of the turbocharger. While the 33C protocol remains relevant for this purpose, turbocharger deposits that are more oxidative in nature and occur at lower temperatures can also be a problem, driving the need for a lower temperature test that also retains volatile components. The TEOST Turbo® test method and instrument was developed to meet this need.

The table below identifies the different testing parameters between 33C, MHT® and the new ASTM D8447 Turbo method.

Parameter	Units	33C	MHT	Turbo
ASTM Method #	-	D6335	D7097	D8447
Rod Type	-	Non Wound	Wire Wound	Wire Wound
Total Oil Volume	mL	116	10	30
Oil Flow Direction	-	Bottom Up	Top Down	Top Down
Catalyst	-	6% Fe Napthenate	MHT	6% Fe Napthenate
Gas Addition Type	-	Moist Air, N_2O	Dry Air	Moist Air
Gas Induction Location	-	Reservoir	Upper end cap	Upper end cap
Peak Rod Temp	deg C	480	285	290
Test Duration	Hr	<2	24	18

With many auto manufacturers choosing to add turbochargers to their vehicles to improve fuel efficiency, this new test method is an affordable option for simulating engine operating environments and certain field performance conditions. For more details, an article related to the evolution of ASTM D8447 posted on our website under Testing Highlights.

ASTM D8447 Test Method Available Now

The new ASTM D8447 test is immediately available at Savant Labs to evaluate your engine oil formulations. In addition, the flexibility of the TEOST® test platform is a great research tool. If you have a specific application that falls outside these specific protocols, don't hesitate to contact Savant Labs. We can assist with your research needs by further modifying a variety of test parameters, i.e., temperature zones, pump speeds, catalytic materials, and other modification options to simulate desired engine operating conditions. Contact us for more information.

Upcoming Events

NLGI 89th Annual Meeting - *Finding the Green in Grease*, in Toronto, Canada on June 12-15, 2022. Please stop by and ask about our recent grease testing capabilities.

NLGI 89TH ANNUAL MEETING
Finding The Green In Grease

ASTM International - D02 June Committee Week, in Seattle, Washington on June 26-30, 2022. Please stop into the Hospitality Suite Tuesday evening and ask about our Electric Vehicle Fluids Testing.

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