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Oil Analysis

Oil Analysis Improves Wind Turbine Gearbox Performance - Part 2

Whitepaper

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Part 1 - Summary & Introduction to Part 2

Part 2 of this paper continues the discussion in Part 1 on the main problems oil analysis can identify in wind turbine gearboxes. Here we will explain how foam, retained air and properly estimating the remaining useful life of the lubricant can directly affect wind turbine gearbox performance.

Figure 1 - Typical wind turbine environment

1. Foam and Retained Air in the Oil

Optimum wind turbine gearbox performance is directly dependent on reducing and controlling air retention and the formation of foam.

The formation of foam in wind turbine gearbox oils can typically be attributed to three factors:

- A mechanical problem within the gearbox
- Trapped air
- Depleted or ineffective foam additive

Figure 2 - Presence of foam in wind turbine gearbox

Foaming may be the result of a mechanical problem caused by excessive agitation or a low level of oil. If foaming occurs but disappears quickly when the machine stops, we must also consider the condition of the oil and the possible ineffectiveness or depletion of anti-foaming additives.

	Air Separation (ASTMD3427)	Foam Stability (ASTMD892)
Mechanical problem	Same as new oil	Same as new oil
Trapped air problem (the oil does not release the air)	Oil increase new	Same as new oil
Depleted or ineffective additive	Oil increase new	Oil increase new

Table 1 - Problems related to foam

Consider the following factors when attempting to eliminate the formation of foam:

1.1. Filling Method

It is extremely important that oil be added using a hose placed in the tank to avoid introducing air. Always purge new tanks after filling to eliminate any air trapped in dead zones. When a new tank is filled, the air can get trapped in dead zones so a purge must be done. The proper procedure is to empty the tank with a vacuum pump and retain the vacuum while filling.

1.2. Proactive Preventive Maintenance

A proactive, preventive maintenance program includes visual inspections of the following at each PM:

- Gaskets
- Oil levels
- Filter performance

Consistent, proactive maintenance practices eliminate foam by:

- Controlling cleaning procedures
- Removing moisture and other contaminants
- Efficient & effective oil filtration

If foaming persists despite thorough maintenance best practices, locate the source of air ingression and eliminate it.

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1.3. Tank Design

Tank design is typically the most common factor contributing to oil foaming for the following reasons:

- Return line is above the oil level
- Tank size is too small – capacity must be between five and 10 times the pump flow or 0.4l/kw is recommended for splash-lubricating systems
- Tank oil level is low
- Moving parts introduce air into the system

1.4. Lubricant Selection

There are large behavioral differences between lubricating oils. Some are able to accumulate large amounts of retained air, but release it quickly, while others allow the entry of only small amounts, but release it very slowly.

Synthetic and hydro-fractionated oils are ideal for controlling foam as they are highly resistant to the entry of air and they do not retain air bubbles if allowed to form.

According to ASTM D3427, the amount of retained air in used oils must not be higher than 25% with respect to oil when new. According to ASTM D892, the maximum level of foam acceptable for used oils must not be greater than:

Temperature	Formation (5'blown)	Stability (10' rest)
24°C	100	10
93, 5°C	200	20
24°C	100	10

Table 2 - Maximum acceptable foam levels for used oils (ASTM-D 892)

2. Remaining Useful Life

Figure 3 - Testing for the remaining useful life of a wind turbine gearbox oil

It is critical that accurate technical criteria be established for determining at what level of degradation the oil should be changed. A predictive method for making this determination is to monitor both TAN (Total Acid Number), ASTM D664 and Kinematic Viscosity, ASTM D445. When the Acidity Index of the oil reaches a value of one over the value of the new oil, degradation is jeopardizing the remaining useful life of the oil.

Voltammetry is another proactive technique for determining the oil's remaining useful life, which does so through the control of the oil's antioxidant additives.

The RULER© is the instrument used to quantitatively determine the remaining useful life of the lubricant by measuring the remaining concentration of antioxidants. The speed at which the antioxidants deplete over time is monitored and then used to predict appropriate oil change intervals as well as identify abnormal equipment conditions before machine failure occurs. The established limit value for wind turbine gearbox oils is 25% of the oil's initial value.

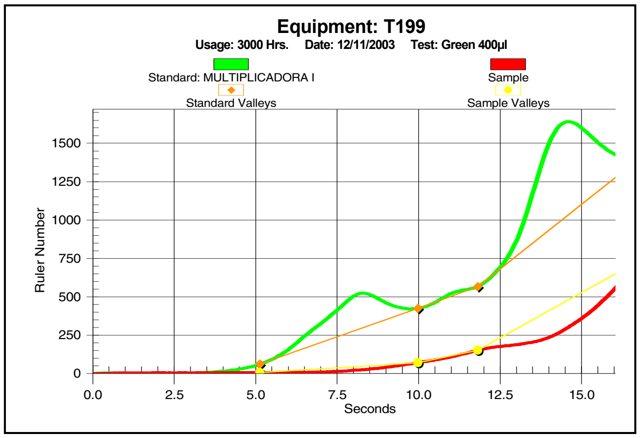

Figure 4 - Voltammogram results for the remaining useful life of a wind turbine oil

Oil	New	3000 Hours Laboratory test
Viscosity @ 40°C (cSt)	314.21	348.97
Viscosity @ 100°C (cSt)	54.32	61.35
Total Acid Number (mgKOH/g)	.28	4.12
Remaining life-Ruler (%)	100	11

Table 3 - Results of a PAG aged in the laboratory for 3000 hours

3. Analytical Testing and Typical Values for Wind Turbine Gearbox Oils

Parameter	Routine	Normal Value	Monitor Value	Danger Value
Viscosity @ 40°C	Normal	New Oil	+/-10%	+/-15%
Viscosity @ 100°C	Normal	New Oil	+/-10%	+/-15%
Acidity Index	Normal	New Oil	0.2 increase with respect to new acidity oil	1 with respect to new oil
Viscosity Index	Normal	New Oil	+/-10 with respect to new oil	+/-15 with respect to new oil
Water	Normal	<50 ppm	200 ppm	400 ppm
Nitration	Normal	<1 abs/cm	<5 abs/cm	<10 abs/cm
Oxidation	Normal	<1 abs/cm	<5 abs/cm	<10 abs/cm
Particle Count	Normal	17/15/12	19/17/14	20/18/15
PQ Index	Normal	50	80	>80
Silicon	Normal	<10ppm	<20 ppm	>20 ppm
Iron	Normal	<40 ppm	<60 ppm	>60 ppm
Copper	Normal	<10ppm	<20 ppm	>20 ppm
Chrome	Normal	<10ppm	<20 ppm	>20 ppm
Lead	Normal	<10ppm	<20 ppm	>20 ppm
Tin	Normal	<10ppm	<20 ppm	>20 ppm
Aluminum	Normal	<10ppm	<20 ppm	>20 ppm
Nickel	Normal	<10ppm	<20 ppm	>20 ppm
Additive Metals	Normal	>50% Initial Value	<50%	<40%
Foam	Exceptional	75/10 75/10 75/10	100/10 200/20 100/10	100/10 200/20 100/10
Retained Air	Exceptional	<15 min.	+20% New Oil	+25% New Oil
RULER (remaining useful life)	Exceptional	>50% New Oil	>25% New Oil	>25% New Oil
Lasernet Fines	Recommendable	No Particles	Moderate	Alto
Analytical Ferrography	Exceptional	No Particles		

Table 4 - Predictive, proactive oil analysis program and recommended value limits

4. Conclusions

1. Selecting the proper lubricant extends machine component life and the life of the lubricating oil. Base lubricant selection on the recommendations of the equipment, filter and lubricant manufacturers.

2. Train maintenance staff to perform accurate, on-site inspections at each regularly scheduled sampling interval. Samples should be taken at 6-month intervals from the same sampling points and by the same sampling method in order to achieve the most accurate and informative trend analysis.

3. Use oil analysis – one of the best predictive/proactive maintenance tools available – to identify changes in both lubricant and equipment condition, such as micro-pitting, retained air, foam and oil degradation. Oil analysis best practices include testing for elemental wear and its severity, contamination, additive depletion and changes in the lubricant's physical properties.

In final conclusion, to reduce or eliminate wind turbine gearbox failures, maintenance best practices must achieve maximize lubricant film, reduce gear surface roughness, eliminate the ingression of contaminants to maintain maximum lubricant cleanliness, control temperature and optimize the performance of all lubricant properties.

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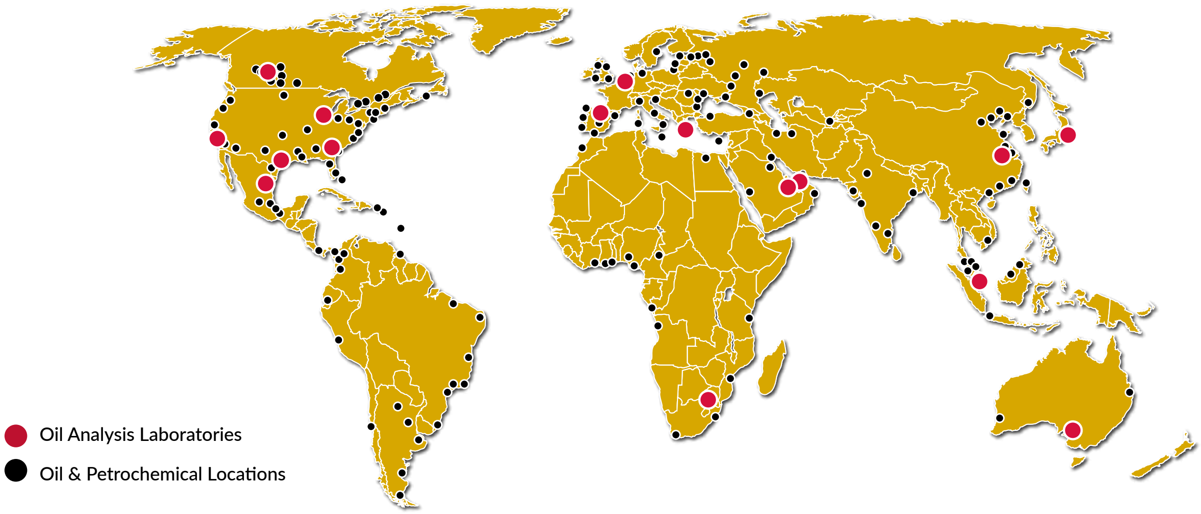

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