Jack Poley

Oil analysis in the real world: Part VI

Specific component types need their own oil analysis testing packages.

Let's pick up from our discussion from the September TLT where we addressed potential issues for diesel engines, which require different testing methods. Now we'll look at our choice of tests for other components.

GEARSETS

Gears lack an oil filter more often than not. This default suggests we need to look at particulate content quite differently from filtered component types.

As you would expect, gearsets with filtration show remarkably less particulate matter overall, even when sampling prior to the oil circuit filter. Prior-to-filter is the correct way to sample a filtered system for condition monitoring purposes and offers the best chance to gather the most amount of evidence for an evaluation. The amount of contamination is significantly less than one would expect to find in a comparable unfiltered system.

There's no surprise, but it does underscore the need to take filtration, or lack thereof, into consideration for both test selection and the evaluation process. Large particle inspection beyond the typical 3-8 μ resolution of emission spectrometers becomes an area of great interest. Larger particles are more significant in terms of possible trauma wherein near-term machine failure is possibly threatened, so there is a potentially critical time window when such particles are in high concentration or substantially increasing.

Following are some recommended test considerations:

Particle quantifier (or similar*). Particle quantifier testing is very popular on gearsets because of the unfiltered nature of most sumps. This technique is based on a ferrous metal's response to a magnetic field and is extremely easy to apply to oil samples, often without removing the oil sample container's lid. While the reporting value is scalar, i.e., without a measurement unit, the values are certainly relative and can, therefore, be assigned limits and be trended.

The only caveat I would suggest is not to take action on the basis of PQ alone. You should utilize it as a very good screening tool and vet abnormal results with additional testing, starting with ppm Fe from a spectrometer.

Particle counting. Particle counting has received much more attention and use in the last decade. It could be useful for gearset applications, provided the concentrations aren't so great that they become meaningless noise or simply inaccurate due to saturation of the PC detection and measuring mechanics. We'll make the reasonable assumption that we'll use PC on filtered gearsets for sure but only on unfiltered gearsets where particle generation is known to be within manageable concentrations, i.e., where the measurement is reasonably accurate and dependable so that equally reasonable and accurate conclusions about machine and lube condition can be assessed.

We divided PC into two groupings: >4/6/14 μ and >21/38/70 μ particle size. The smaller particles are the core

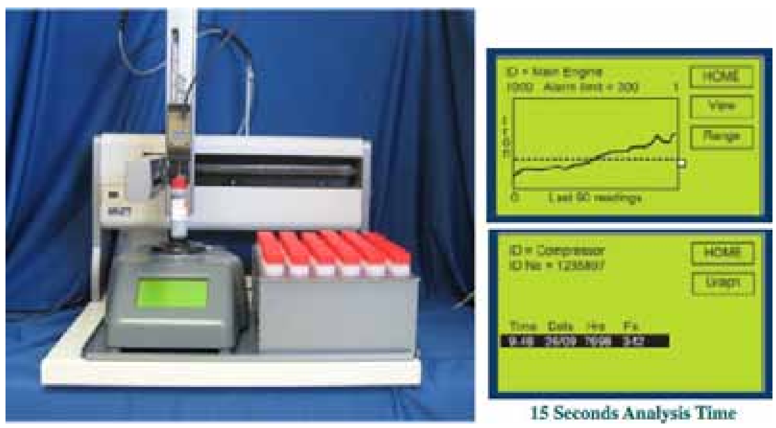

Figure 1 | **Ferrous debris analyzer.** *(Courtesy of Kittiwake Developments Ltd.)*

*Another, more recent, development based on PQ technology does provide ppm Fe because the sample can be entirely immersed in the magnetic field, allowing a quantitative result *(see Figure 1)*.

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values for determining the ISO Cleanliness Code or the ISO number, as we in the industry tend to compress it. The three larger sizes represent debris of varying sorts (Note: a typical PC furnishing ISO number does not reveal anything about particle composition).

It is certainly possible, and not entirely unusual, for a lube to have a satisfactory ISO number and also have abnormal numbers in the 21/38/70 µ ranges which again are not considered in the ISO number. There are several factors that could be responsible, including:

- A poor sample may have been collected (trash particles) or poor practice in top-up or refill may have occurred.
- Wear trauma of a fatiguing nature may be indicated.
- A seal or breather may be compromised, allowing dirt to enter.
- Combinations of the above may simultaneously exist.

Other testing, of course, would be necessary to isolate the most likely problem. If wear levels and rates do not show any increases, perhaps a resample would be appropriate. However, one should be mindful that spectrometric metals analysis is virtually blind to particles larger than 10 µ. Micropatch testing or analytical ferrography might be employed.

Added Laser Net Fines text

Spectrometric metals. While we note the particle size detection limits, this test still offers far too much value for the cost, so never eschew it.

First, wear metal concentrations may present the following:

Change These two bullets

- If the basic wear occurring is of a small-particle nature.
- When fatigue does set in, small particles may be the first sign or they may be generated simultaneously with the larger particles.

Second, the detection of possible contaminants such as Si, often an abrasives indicator, is valuable. Lastly, additive metals may help confirm that proper (or incorrect) lube is in the sump.

Water. I continue to be skeptical about accuracy of samples secured for water concentration testing, but one still needs to know if water contamination is a possible issue. As noted in previous columns, I favor an online sensor that specifically measures water concentration (*see Figure 2*). An oil condition sensor that relies on dielectric measurements also detects water but must be further vetted through onsite or offsite testing. (Pssst: If one has the means to heat a piece of metal to, say, ~300 F and dip it into a sample of the lube, it will cause a sizzling sound that will confirm significant water is present. This isn't a recommendation—it's just a fact).

Figure 2 | **Water content sensor.** *(Courtesy of Kittiwake Developments Ltd.)*

For gearsets a properly calibrated and standardized infrared analytical method (FTIR) or a crackle test would serve as the trigger, if positive, for Karl Fischer water measurement in ppm. The KF water may not even be necessary, dependent on the significance of water in a particular sump. If the only action to be taken is to drain off the water or drain the sump completely, why bother to determine the supposed concentration? If the system is considered very sensitive to water, that's a different matter.

Gearsets often work in damp environments or are directly exposed to water being splashed on their housings in the course of normal operation. In such cases, some water is inevitable via breathers and other ingress points. The application determines the level of effort for water detection/measurement.

Fourier Transforms Infrared Analysis. Fourier Transforms Infrared Analysis is pretty much a de facto standard in used-oil testing, much as metals spectroscopy has been. While it provides a lot of bang for the buck, it is at times misused or, rather, mismanaged by some testers, resulting in unreliable or fictitious data. I made mention of this in previous columns, but it bears repeating.

With that said, one gains oxidation indications in gearboxes (some synthetics pose a problem with this measurement—you should check with your oil company, accordingly).

Acid number (TAN). There is occasional value in performing acid number testing in gearsets. However, if one finds little or no movement in the test data over time, it may well be abandoned. Probably the best approach is to extract the AN from FTIR, if available, rather than incur the expense of an added test setup. Not withstanding FTIR, ASTM D664 is the recommended method.

AN, as a weak organic acid, should correlate somewhat with oxidation readings; if not, it may indicate the presence of a contaminating acid from the machine's environment. Some plants have acids normally in use, and breathers on gearsets may allow ingress in small quantities.

Viscosity. Gearset fluids are typically tested at 40 C rather than 100 C, unless a viscosity index is desired, requiring both temperatures' results for the VI calculation. Typically VI is not useful in used fluids, except for research studies.

We have enough tests to propose the following gearset suite:

- **PQ (or similar):** To screen for ferrous debris, particularly in unfiltered sumps.
- **Particle count:** Particularly where filtration exists or where a system operates at sufficient cleanliness to render the test valid and reliable.
- **Spectrometric metals:** Mandatory
- **Oxidation (FTIR):** Usually via FTIR for mineral lubes. If AN is achievable, as well, it is a welcome addition. Water screening can also be satisfied properly.
- **Water (ASTM D95, KF, Crackle, FTIR):** One should always know if water's there, so do something. Choose the method and testing sequence, if any, based on asset criticality and sensitivity to water.
- **AN (ASTM D664 or FTIR):** May be optional. If available free from FTIR, that's plenty good enough.
- **Viscosity (usually 40 C):** Mandatory.
- **Micropatch or Analytical Ferrography:** Invoked as appropriate for decision-making as to a teardown for wear or other trauma inspection.

Added bullet for LaserNetFines

Italicize this word

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