Understanding lubrication analysis

by Jack Poley

We continue our discussion of metals analysis that we touched upon from the previous column.

There are now two DRS types in use:

- **DRE or Rotrode.** This instrument functions essentially the same as Walter Baird's original DRS and utilizes high-purity carbon electrodes, one a disc that rotates for sample uptake, the other a pin to complete the electrical arc/spark path, to energize the oil sample in order to ionize and measure elements of interest.
- **ICP or Inductively-coupled Plasma.** This instrument, like the DRE, accomplishes its analysis similarly to a rotrode unit but uses a plasma source as its excitation and, therefore, no electrodes. The sample is aspirated into the plasma flame, which requires solvent dilution with the attendant problem of additional disposal. On the other hand, the ICP is more adaptable to automation and has often demonstrated sensitivity beyond DRE instruments.

Larger particles, however, give both instrument types problems with detection. While the carbon/graphite furnace AA method achieved 'total' particle analysis, it could not distinguish the relative sizes of particles, thus one still had no indication of the size distribution, let alone morphology.

A modification to the DRE technique, known as "rotrode filter spectroscopy" [RFS], avails itself of the porosity aspect of the DRE carbon disc, using the disc first as a filter, trapping larger particles, then using the disc as an electrode in the conventional DRE technique. RFS is able to distinguish large vs. small particles for each wear metal by performing a 'double' analysis, one with filtration and particle trapping, the other without. The primary drawback is that quantification is not yet possible with this technique, so it is probably best currently used as a trigger for more rigorous inspections such as particle counting or microscopic examination (including analytical ferrography).

As well as the obvious need to simply detect wear in high-speed rotary systems, i.e., detect and identify large particles, there was a need to know wear particle size distribution, in order to understand the nature and criticality of the machine's wear.

Starting in the early 1970s, a number of techniques addressing large particle analysis were both developed and/or made practical for the fluid analysis testing platform. Some examples:

Particle Counting. This technique is very straightforward. A sample is analyzed for particulate detection and size range, usually from 4 microns[1] through 100 microns in five or six range stages. Numbers of methods exist, all descendants of a U.S. armed services technique (ARP598) that simply viewed filtered deposits under a microscope with a sizing grid in the ocular and a hand-operated counter. Tedious, but effective.

Nowadays, lasers or physical screens are utilized to sense the particles; detectors integrated with computerized data acquisition render particle counting relatively quick and routine, provided one is careful in the sampling and handling processes.

Ferrography. Developed by Vernon C. Wescott et. al., ferrography takes advantage of the magnetic nature of a great number, often the preponderance, of wear particles. There are two types of ferrography:

- Direct Reading Ferrography [DRF] separates magnetic particles at roughly 6 microns, theoretically dividing small, benign ferrous particles from large, fatigue-oriented ferrous particles. This technique can be useful as a screening device for its more sophisticated sister test.
- Analytical Ferrography [AF] is one of the most revealing inspections available for fluid analysis. AF is a two-stage test that consists of the preparation of a special microscope slide, wherein magnetic particles are systematically deposited and oriented perpendicularly along the slide's axis, and where non-magnetic particles deposit somewhat randomly. After a cure time the slide is viewed with a bichromatic microscope, allowing identification of numbers of particles by type, morphology and estimated quantity. Once the ordered deposition is achieved, morphology, or shape identification, is perhaps AF's most discerning facet, greatly helping the evaluator in characterizing and assessing wear. <<

[1] *In an effort to be more accurate the ISO particle count scale was revised. Particles previously classified at 5 microns are now classified as 6 microns, particles previously classified as 15 microns are now classified as 14 microns. 6- and 14-micron levels are used to determine a standard ISO code classification. 2-micron particles are now rated as 4-micron particles. Previous data are not affected by this decision because only nomenclature has changed.*

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