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Use of Imaging Instrumentation to Analyze Antifoam Constituents in Lubricating Oils and Distinguish Them from Contamination and Water

Author:
Thomas M. Canty, P.E.
President/Owner
J.M. Canty Inc.
Buffalo, NY

Imaging is becoming an important tool in the analysis of lubricating oils due to its visual capability to discern between types of particles by shape. Laser and light obscuration devices cannot indicate shape characteristics of particles. The particle count per mL obtained does not reveal the true condition of the oil because all detections are treated as solid detections thereby yielding no data on water content or constituents such as anti-foam. The end result can be a determination of contamination levels that are overstated which can increase costs due to premature replacement of lubricants that are still in good condition.

In cases where lubricants contain water simple image, filters can discern them and report them separately from solids content. A test of jet fuel for solids and water is shown in Tables 1 and 2 which compare the results from an imaging instrument to a light obscuration instrument. When water is added to the baseline dry fuel the laser instrument records a much higher solid content which is all it can do as there is no provision for detecting or reporting water. The imaging instrument does not show a change in the solids content.

***Table 1. Laser-Based System, Dry Fuel vs. Wet Fuel Solid Counts**

	Dry Fuel			**Fuel with 5 ppm Water**		
Trial	>4	>6	>14	>4	>6	>14
1	1751	437	2.1	2970	1529	543
2	1630	406	2	2476	1165	372
3	1537	378	2	2414	1160	382

***Table 2. Imaging System, Dry Fuel vs. Wet Fuel Solids Counts (Uncalibrated)**

	Dry Fuel				Fuel with 5 ppm Water			
Trial	>1	>4	>6	>14	>1	>4	>6	>14
1	25	9	1	0	19	8	1	0
2	26	13	8	1	15	7	1	0
3	18	5	1	0	14	8	2	0

**Data from US Army TARDEC technical report, January 2016, Utilization of Automated Imaging for the Detection of Fuel Contamination, J. Schmitigal, K. Petersen.*

For cases where anti-foam is concerned, identifying these constituents in a reliable way is a much more complicated task. Figure 1 shows a typical anti-foam particle. Using simple mathematical filters such as aspect ratio or circularity aren't sufficient to define these and so even an imaging instrument can have difficulty sorting things out. To do this properly greater sophistication is required and can be obtained by using a neural network-based algorithm which identifies particles by comparing similar features from one to another. In this way features, that probably can't be described mathematically, can be identified by their similarity to other particles of their type.

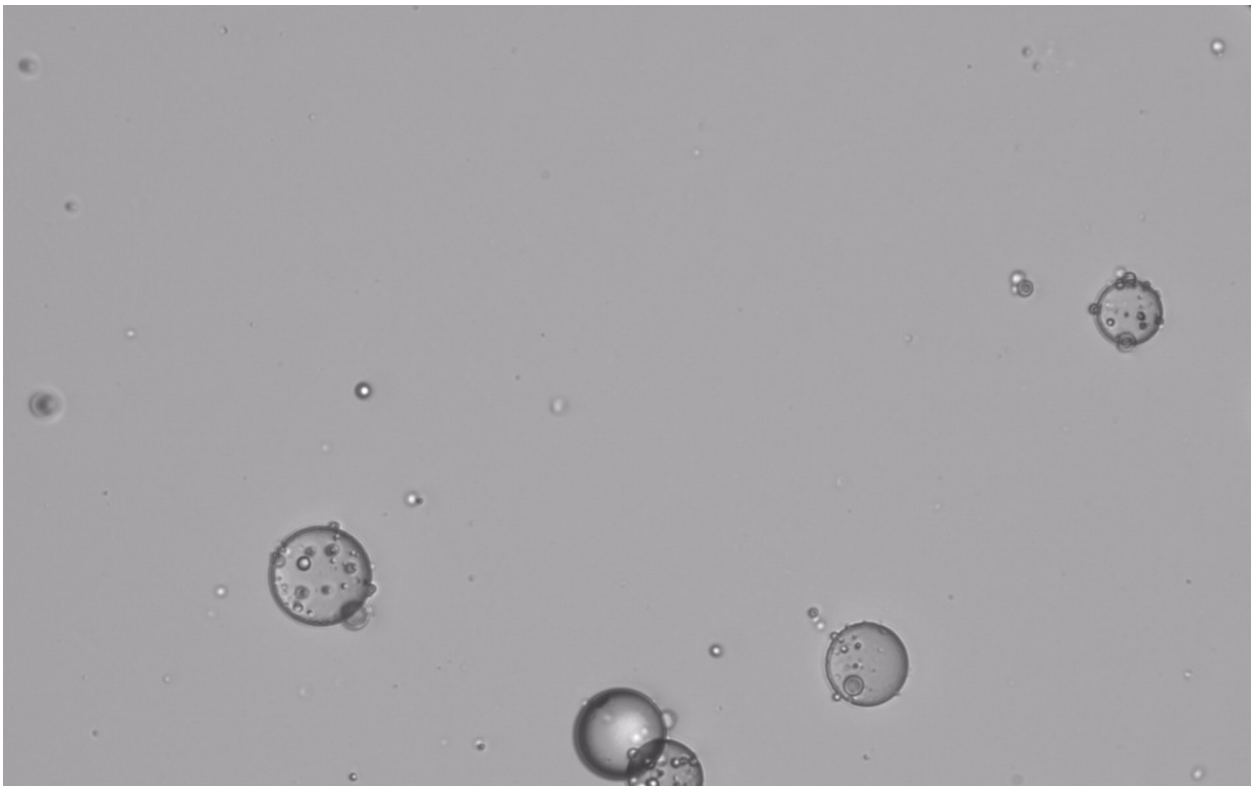

Figure 1. Typical Anti-Foam Particle

In a test case, lube oil, with anti-foam additives, was analyzed using an imaging system. Simple filters either removed most particles, or kept most in an effort to separate the anti-foam from normal solid particulate. Results showing high counts of particulate are compared to results

obtained using a neural network algorithm and the same instrument. Notice the decline in particle count using the more sophisticated detection method. This allows the oil to be analyzed for solid contamination with a much greater degree of precision than before.

Table 3. Particle Count/mL; Anti-Foam Filter vs. No Filter

	Anti-Foam Filter			No Filter		
Sample	>4um	>6um	>14um	>4um	>6um	>14um
1	211.3	158.5	0	602	0	0
2	0	0	0	1490	1261	344
3	0	0	0	4922	3662	911
4	52.4	0	0	2161	1359	120
5	0	0	0	1203	1094	0
6	0	0	0	344	229	0
7	263.7	105.5	0	2636	1719	688
8	521.6	0	0	3896	1146	344
9	205.7	0	0	1375	573	0
10	8983.5	449.2	0	9080	1203	109
11	7363	252.2	0	8095	1313	328
12	9449	250	0	7876	875	219

This also has application in identifying solid particle contamination causes. ASTM D7596 lists general particle characteristics to help identify causes that generate particles such as fatigue wear, sliding wear etc. Grouping particles based on their like features should prove a much more accurate and reliable method of identification. Particle analysis in other industries can also benefit from this technology. Frac sand particles are also classified by their shape, in addition to their size, per API Recommended Practice 19c which describes varying shapes of sand particles which impacts the quality of the sand. Differences are subtle and mathematical filters do not have the resolution to define differences in these particles well enough to accurately categorize them with any reliability.