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Inspect for Success with Visual Oil Analysis

by Mark Barnes

Figure 1: A 3D sight glass is much easier to read than conventional flat sight gauges

As a scientist by training and an engineer at heart, reliability engineering is a fascinating subject, replete with neat technologies, like vibration analysis, ultrasound, ferrography and oil analysis. To the geeks among us, there's nothing more magical than trending bearing defect frequencies, recording decibel readings, observing severe sliding wear particles on a microscope slide, or interpreting acid numbers.

But while the value of these technologies cannot be overstated, there's something to be said for the powers of human observation. You see, many lubrication-related problems are not deep-seated in the intricacies of elastohydrodynamic film thickness or boundary lubrication, but are basic errors of human judgment, or simple issues related to how a machine is operating within its environment. As such, there are some very basic–but insightful–visual inspection tools that, when executed properly, can become a powerful complement to the more sophisticated predictive maintenance technologies we all know and love.

What Is Visual Oil Analysis?

To most people, oil analysis means taking a four ounce sample bottle of oil and sending it to a commercial oil analysis lab for physical and chemical analysis. However, many basic lubrication problems can be found just by simple visual inspections, referred to as visual oil analysis (VOA). Here are just a few of the things that can be found using VOA.

Correct Oil Level

Having the right amount of oil in the machine–particularly in wet sump applications like pumps and gearboxes–is critical. Take, for example, the element bearings in a small API or ANSI pump. The correct oil level is halfway up the rolling element at the bottom of the bearing. Any higher and you run the risk of fluid friction and excess heat and/or leakage, and any lower and the bearing may become starved of lubricant. This is particularly relevant when you consider that the physical size of a rolling element in a small ANSI pump may be only one-half to three-fourth inches, meaning the oil level must be maintained around one-fourth inch to ensure optimized lubricant level.

Of course, many small pumps are fitted with constant level oilers to maintain oil level for this very reason**. But these never should be used as a way of checking oil level.** While the glass bulb may appear full, any small restriction in the narrow bore tube that connects the oiler to the bottom of the oil sump can prevent oil from flowing into the bearing housing. There have been many instances where the bottle oiler is full, but the oil sump has very little oil left!

Of course, most pumps also have a standard sight glass, which is designed to allow mechanics and operators to inspect for the correct oil level within the pump. However, over time, these become stained and discolored, making it difficult to check the oil level in a dark process plant. A much better option is to use a 3D sight glass, such as the one shown in Figure 1, which permits the oil level to be viewed from any angle. Used with a strong flashlight or laser pointer, a 3D sight gauge is a far more reliable option for ensuring the proper oil level in pumps and small gearboxes.

In some instances, wet sumps do not have sight glasses, but rather an oil dipstick or a thread plug at the correct oil level. While in theory both work, in reality neither are very effective. With dipsticks, the only real way to check the oil level is to shut down the machine and wait for the oil to drain to the bottom of the oil pan. But in most plants, shutting down equipment simply to check the oil level is simply not an option and, even if this is feasible, the dipstick port becomes a source for contaminants to enter the machine.

Oil level plugs also tend to be less than effective. In most plants, operators and mechanics simply do not have the time or motivation to remove a plug and check for oil on every piece of equipment. Furthermore, having the machine in operation impacts the accuracy of the level check.

Figure 2: Column level gauges are a great way to quickly and simply check oil level, but any level gauge should be marked with the oil level when the machine is running (red) and shut down (green)

Figure 3: Installed at the lowest point on a wet sump, a BS&W bowl is an excellent way to observe free or emulsified water in oil

A much better option for when the housing does not have a sight glass port at oil level is to use an external level gauge. With a properly installed level gauge, checking the oil level takes a matter of seconds and is much more likely to actually be done regularly. Any liquid level gauge should be marked with level markers, as shown in Figure 2, showing the correct level when the machine is running and when it's down.

Free and Emulsified Water

With 60 to 70 percent of all lubrication-related problems caused by contamination, visual oil analysis is also a great tool for determining the presence of contaminants, particularly water. Even with the use of desiccant breathers, water still sometimes enters a machine through poor sump management, dirty new oil, shaft seal ingression, or packing leaks. Because of this, inspecting for water in any lube oil system is important. Water in oil can either be free (separated on the bottom of the sump) or emulsified (mixed with oil in a cloudy suspension).

If one waits until the oil in the sight glass turns cloudy, it's often too late. A better option is to install a small, clear inspection tool on the bearing drain, something often referred to as a bottom sediment and water (BS&W) bowl. Installed correctly at the lowest point of the system, see Figure 3, a BS&W bowl can be used to find the presence of water before it impacts the bearing.

Figure 4: Using a color comparison chart in conjunction with a column level gauge is an excellent tool for determining changes in oil chemistry over time

Oil Color

Surprisingly, oil color also can be a good indicator of a problem. A number of issues can cause an oil to change color, including oxidation, thermal stress, external contamination, or the presence of wear metals or other debris. Whenever oil is observed to have changed color, it's usually a good idea to extract a bottle sample and perform additional diagnostic tests. It should be noted that not all color changes necessarily mean something is wrong.

Many lubricants will change color in sunlight or other strong light sources due to an innocuous photocatalytic process. Having a liquid level gauge or 3D oil sight glass is great for determining changes in oil color over time, particularly if used with a color rating chart, see Figure 4, analogous to other chemical testing kits, such as soil testers or pH paper.

Oil Clarity

In addition to the color of the oil, its clarity also can be measured. To do this, a 3D sight glass or level gauge in conjunction with a laser pointer is an ideal tool. Just like shining a laser pointer through a glass of water versus a glass of milk is markedly different, a change in the oil's turbidity or opaqueness can be an indicator of a problem. These include water, solvents, detergents, the wrong lubricant and aeration.

Whenever a change in oil clarity is observed, a bottle sample should be taken for a static sit test. Simply sit the bottle on a desk or window ledge out of direct sunlight and observe how the clarity of the oil changes over the next few minutes, hours and days. This also can be combined with a simple field demulsibility test, see Figure 5. Simply add five to 10 percent by volume of water to the oil and shake vigorously by hand for two minutes. Just like the static sit test, leave the oil to sit for a few hours and observe how the oil and water interact. If the oil is in reasonably good shape without major chemical contaminant impurities, the oil and water will separate. Note any change in the clarity of the oil layer. If it's clearer than before you added water, you probably have some kind of aqueous or other polar contaminant present.

Putting It All Together: Developing Inspection Check Sheets

In watching NFL football, fans often celebrate the quarterback, running back or wide receiver, believing these stars of the game are the keys to winning. Just as important–and some may say even more important–are the offensive and defensive lines because without basic blocking and tackling, the stars can't do their jobs.

Figure 5: Simple field demulsibility tests can be very insightful in diagnosing the source of clarity problems within an oil sample

In maintenance, many of the "star" technologies, like vibration or ultrasound, provide limited value without the basic "blocking and tackling" of good alignment and balancing, along with the right lubricant in the right quantity that's clean, dry and cool. As such, visual oil analysis plays an important role in ensuring the "rights" of lubrication are done correctly.

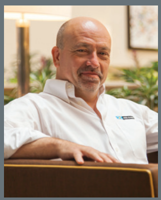
Visual oil analysis tasks should be included as part of daily or weekly rounds. Ideally, these should be done by operators as part of their daily work, but, at a minimum, weekly mechanic rounds should be introduced. Inspections should be set up in a check sheet fashion. Rather than simply state, "check pump," the check sheet should have a series of questions with binary answers. For example:

- Oil level: Low or High;
- Free water present in BS&W bowl: Yes or No;
- Desiccant breather color: Blue or Pink.

Making questions binary takes away any subjectivity and permits task-specific training so the operator understands what he or she is looking for. Even better, include a picture of what "good" and "bad" looks like as part of the inspection check sheet. These inspections should also include other basic mechanical integrity checks so mechanics are not constantly visiting the same pump for different reasons.

Conclusion

As much as professionals in the lubrication community would like to believe, lubrication will never have the same sizzle as technologies that require gadgets, gizmos and data analysis. But unless the basics of lubrication are done correctly and inspected routinely through visual oil analysis, the only thing all those "star" technologies will tell you is that you should have done a better job at lubrication "blocking and tackling." So don't just take lubrication for granted; inspect for success!



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