LUBE-TECH

NO.39

‘BACK TO BASICS’

In the fourth of a ‘Back to Basics’ series, Martin Williamson of independent oil analysis and machinery lubrication training and consultancy firm Noria UK, looks at the issues of measuring solid particle contamination on site.

Low-Down on Particle Counters

Anyone who has attended one of Noria’s oil analysis classes, or any class with a proactive maintenance focus, knows that particle counters should be at the top of the shopping list when setting up an onsite oil analysis program. In fact, if you’re already operating a vibration-focused monitoring program, or have established a good relationship with your filter supplier, you’ve probably been offered an automatic particle counter (APC) at one time or another. However, not all things are equal in the world of particle counters or monitors. There are many factors that should be considered before purchasing a particle counter or monitor.

The History of Automatic Particle Counting

Automated light blockage particle counting technology was first introduced in the 1960s. The basic function of a light blockage APC is simple; a beam of light is projected through the sample fluid, if a particle blocks the light, it results in a measurable energy drop that is roughly proportional to the size of the particle.

Modern particle counters now use a laser beam as the light source, as opposed to the earlier white light units. The highly focused light emitted is interrupted by a particle, producing a shadow or, on some, a scattering effect. The increase in energy across the sampling area is measured with this type of particle counter, just the opposite of the light blockage method (Figure 2). There are very few laser sensor OEMs despite the variety of instruments available on the market. Many have been repackaged and own-label-branded.

The original automatic particle counters (APC) were calibrated using latex spheres, which lead to software that calculated shadow areas as circular dimensions. However, these latex spheres are no longer used in the calibration of APCs for oils because, among other things, the latex swells and creates inaccuracies.

A sample of oil may contain a multitude of problems, which may interfere with the goal of accurately counting and sizing the solid particles. The most common problem is entrained air bubbles and water droplets, which scatter and block light, and are erroneously counted as particles by the optical APC. This method is not suitable for emulsions of oil and water that are commonly used in hydraulic systems for their fire-resistant properties. Without special sample preparation, an optical particle counter does not work well with fluid that is dark or fluids that are heavily contaminated with silt or soot. These conditions can produce so-called coincidence error, or in extreme cases may completely prevent the transmission of light. Current research is trying to identify if problems with water glycols and soot-laden oils using laser-based light scattering APCs can be overcome successfully for consistent use in the field.

As an alternative approach to historical light-blockage technology or the more modern light-scattering technology, Dr. Trevor Hunt and James Fitch independently patented variations of mesh or pore blockage measurement. The basic principle is the same for both methods - particles produce a measurable blockage of fluid flow through a calibrated mesh screen. In the Hunt version, the instrument measures pressure differential across the screen, so the rate of flow must be held constant. The Fitch method measures flow rate decay downstream of the screen, requiring that the applied pressure be held constant (Figure 3). In both cases, the focus of the measurement is solid particulate. The presence of air and/or water in the fluid does not affect the accuracy of a pore-blockage particle counter, nor does the fluid’s colour and/or opacity. However, while generally accurate in measuring the total concentration of solids above the pore size of the screen being used, the pore-blockage type particle counters must estimate the size distribution of particles by extrapolation, and thus, do not conform to use with the ISO standards relating to APCs, but, this does not mean that they cannot be considered as a serious tool in the Condition Monitoring arena. Pall Corporation and Rockwell Automation Entek now own the Hunt and Fitch patents respectively, and are therefore the only two companies marketing units employing mesh blockage.

Still another option is the new image analysis technique, the

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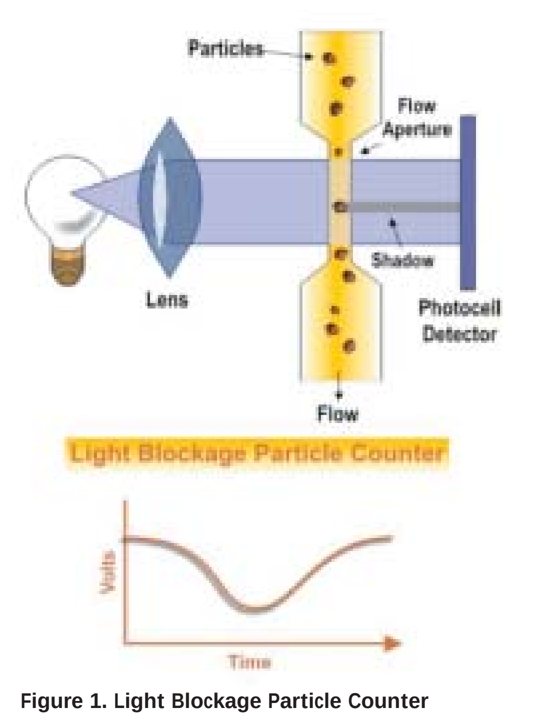

Figure 1. Light Blockage Particle Counter

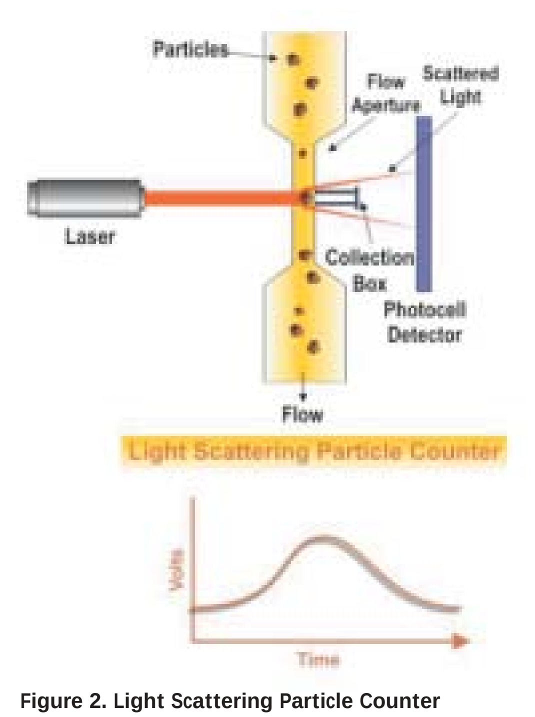

Figure 2. Light Scattering Particle Counter

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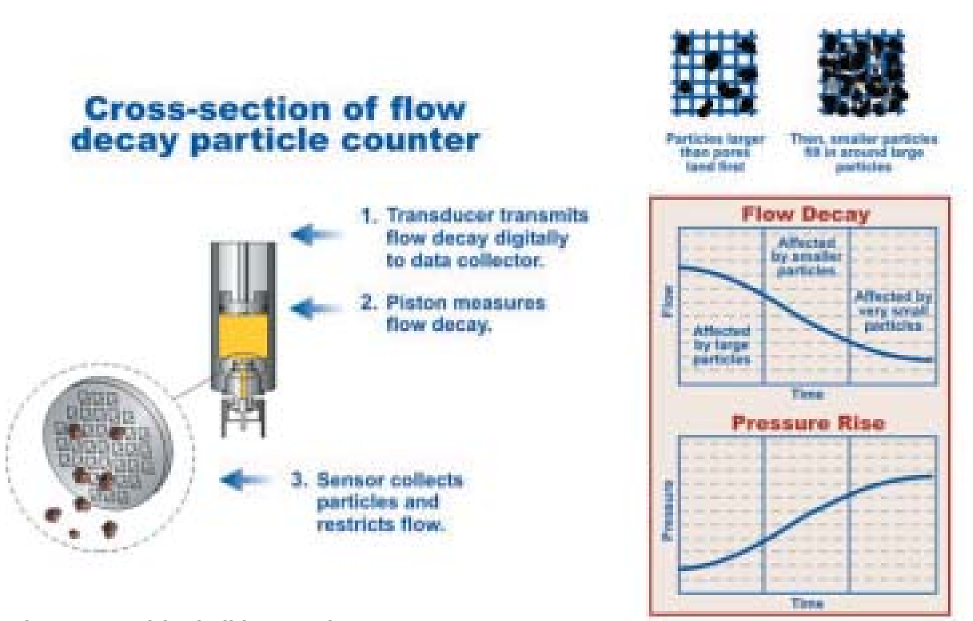

Figure 3. Particles build up on the Screen.

Laser-Net Fines, which takes an entirely different approach to particle counting. Fluid flowing through the test area is digitally photographed. The surface area of a particle is measured on a two-dimensional plane, and then recorded for counting purposes. The shape of the particle is simultaneously evaluated during the test; so in addition to classifying the particle by size, the instrument classifies it in general terms of the wear mechanism that might have produced it. This shape, or morphological analysis capability, enables the instrument to exclude perfectly round particles from the count, which are presumed to be air or water. Consequently, in addition to discriminating air and water from solid particles, the image analysis technology can provide some information about air and water content based upon the roundness and/or opacity. To a degree, this offers wear debris analysis with particle counting.

Unravelling The Dilemma

There are numerous optical units and two pore blockage units on the market. Not all particle-counting units offer the same performance or specification. Likewise, there is disagreement among the experts as to whether pore blockage constitutes particle counting or solid contaminant trending. This results in uncertainty about which type of particle counting or monitoring device the in-plant lubricant condition monitoring or quality technician should purchase.

There are numerous factors to consider when purchasing a particle counter or monitor. These include (not in any order of importance) the demand for distribution accuracy, the types of fluids tested, the contaminants that will typically be encountered, the complexity of procedural requirements and several indirect factors that could influence one's choice.

Particle Distribution Accuracy

When considering the purchase of a particle counting or monitoring device, one must decide if particle counting or trending of the concentration of particulate is the ultimate objective. A particle counter may be required if the particle count will be used to certify fluid cleanliness or if general research is the intent.

Optical particle counters estimate the size of each particle based upon the change in light energy across the sample flow area in the instrument. A large energy depression, if it is a light blockage particle counter, or a large energy spike if it is a light scattering particle counter, suggests a proportionally large particle. While error can result due to the orientation of the particle and other factors, the optical method is generally effective at estimating the size of each particle. The pore blockage counter does not count particles individually; rather it measures the collective influence the entire population of particles has on the fluid flow through the screen. A particle count requires a measure of several different sizes of particles. This is particularly true in the case of the SAE AS 4059 standard (replacing the now defunct NAS 1638), which defines a number of size ranges to be measured, and requires a particle count using a microscope or optical APC. If particle size distribution is important in an advanced onsite oil analysis program, then an optical APC is required.

In a proactive onsite oil analysis program, where the primary objective is to measure and trend the overall cleanliness of the fluid, both the optical and pore-blockage methods will work. The optical method may require considerably more attention to procedural detail and may not be suitable for some fluids, but it does offer the flexibility to analyse the particle size distribution, should that be required to ascertain the wear progression. The pore-blockage method is procedurally simple – either connect to the system or shake the sample bottle and test.

Fluid Types Tested

In addition to the need for distribution accuracy, one must also consider the fluids used and typical contaminants in the various applications to be monitored. As previously discussed, optical particle counting is influenced by a number of factors - aeration, water, dark fluids, heavily contaminated fluids and sample preparation. Most of these factors can be corrected by sample preparation procedures. Otherwise, optical APCs are best applied to machines where the fluid is typically clean, dry and clear (for example, hydraulic systems and turbines), but not suitable for emulsions or dark oils, such as diesel engine oils and some gear oils.

Some argue that counting the water and aeration is important when identifying the inclusive contamination level; others say it's important to adhere to the definition of a solid particle count and the attendant international standards. As such, it may be preferable to employ an alternative method that can effectively discriminate between different sources of measurement variation (discriminant validity).

The pore blockage method does not employ any light source, so factors that influence the transmission of light do not affect its performance. It has proven to be suitable to test dark oils such as engine oil as well as light oils. Water and air don't affect its performance, so emulsions and invert emulsions of oil and water may be tested with this method.

Procedural Requirements

To obtain an accurate particle count, the particles must first be homogeneously suspended in the sample, the way they are in the machine, then tested within a few minutes of agitation (the allowable time depends upon the fluid's viscosity and the nature of the solid particulate in size and specific gravity terms). To achieve this homogenous suspension, one must use a violent agitating device, such as a paint shaker, which might be found in a hardware or building supplies store to prepare the paint for use. This vigorous shaking does induce aeration, but many commercial laboratories avoid this by gently rolling the sample bottle for a period of time on a special rolling device.

After shaking, the sample must be prepared to eliminate interferences. With optical particle counters, it may be necessary to screen for water. If water is present, the sample must be vacuum dehydrated or treated, such as with a solution of toluene and isopropanol. The water dissolves in the isopropanol, the isopropanol dissolves in the toluene and the toluene dissolves in the oil. CSi recommends this method for sampling with their Mini-Lab. When the water is dissolved this way into the oil, it can't interfere with the particle counter. If the fluid is treated for water, it will be necessary to re-suspend the particles using the paint shaker.

Once the sample has been cleared with respect to water, the air must be eliminated. Two methods are identified in ISO 11500 - an ultrasonic bath, which serves to coalesce the bubbles, and vacuum degassing, which pulls the air bubbles out of the oil. Most prefer that both be used - first the ultrasonic bath, then the vacuum chamber.

When using either light or mesh technology units online, it is necessary to allow sufficient flushing time to ensure the unit's sampling hoses are thoroughly clear before accepting a reading. The flush time on some units is fixed, while on others, it can be overridden by the user, which can be advantageous when doing research at a fixed location. In this instance, ensure that the set-up parameters can be configured and they are consistently set for each application to avoid erroneous data. Once the sampling location and oil has been qualified as free of water and air, and the instrument adequately flushed, it is ready for testing.

Miscellaneous Considerations

Here are a few other things to consider in your choice of a particle counter:

Sample/Machine Identification - It is important that the ability to enter a fixed identity such as from a bar code or radio signal from the port into the unit's memory while conducting a test is available. This minimises errors and results in the accurate uploading of data without accidentally creating new identities in the software's plant and machine train hierarchy.

Some people prefer, when working with optical APCs, for an onboard pump to control the flow rate. Although, in portable units, this means that a waste hose will need to be directed to the tank or waste container. The convenience factor allows for an online sample to be drawn from a tank or reservoir.

When selecting a portable walk-around unit, for ease of operation, ensure that it is comfortable to carry, preferably with a suitable case or bag that allows for storage of the additional items like the hoses.

When selecting a bench-mounted system, ensure that it fits comfortably within the work area with access to power and possibly vacuum or compressed air for the bottle-sampling unit.

If no flow lines exist on the machine for which online monitoring is desired, it may be necessary to purchase a unit with a built-in pump that can extract a sample from sumps and tanks. While these models have a drain line, they may not reach a suitable disposal point in the system, so a small waste container may be necessary for the flush and sample fluid. You should avoid pouring this fluid back into the system unless the container is immaculately maintained and there is no cross-contamination risk.

As with any unit, regardless of its intended use, consider the location of the service centre, its ability to quickly repair or service the instrument, or to loan out equipment if necessary. Also consider the operational costs, the frequency of calibration and whether a calibration validation can be done onsite by a competent technician.

In the civilian aerospace industry and automotive manufacturing sector where certain ester-type fluids are used, a unit with special seals and materials is required.

When using an optical particle counter online, ensure that the line pressure is sufficient to eliminate interference from air bubbles, or that the particle counter itself deals with the air.

Application and Use

Ultimately, the application should dictate your choice. Particle counters are used in a number of different applications, including commercial laboratory oil analysis, small onsite oil analysis laboratories, in or online continuous machine monitoring, walk-around condition monitoring, tests stands and flushing rigs to name a few. The particle counter you select should best suit your specific application:

Onsite Machine Condition Monitoring and Contamination Control

The choice for an onsite machine condition-monitoring application is between bottle samples and direct online measurement - permanent or periodic. Typically, it is useful to have both capabilities, of course, as other routine oil tests (like water and viscosity) can be conducted on the same bottle sample. On the other hand, a permanent mount or portable unit may be justified for a critical machine. For walk-around measurements with a portable unit, primary and secondary connections to a system allow non-conforming tests to be repeated immediately and possibly allow troubleshooting of the problem (such as inspecting filters and breathers). This will require quick-connect fittings, and some units may require a custom manifold. Most portable particle counters work with the Minimess-style fittings, but one should install sampling valves and ports carefully - avoid long, stagnant pipe lengths and laminar flow zones, or areas where significant pockets of air may exist.

If you desire portable walk-around particle counting, many optical particle counters and both pore-blockage particle counters can accommodate this need, with varying degrees of simplicity. If you desire full-time, online particle counting, the optical and pressure differential pore blockage methods will work.

The question of whether an optical APC or a pore-blockage device better suits you comes down to the fluids you are testing, your demand for particle size distribution accuracy, procedural simplicity and the other considerations previously discussed. If you primarily test systems with clear, clean oil such as turbine oil and hydraulic fluid, either technology will work, although optical APCs would be the better choice. If you test a wider range of fluids that might include engine oils or other dark fluids, water-based fire resistant fluids, heavy gear oil and/or heavily contaminated fluids that frequently contain water, the pore-blockage method may provide you with more flexibility.

If particle counting is considered as an extension to a vibration analysis (VA)-based machine condition-monitoring programme, that VA hardware and software supplier may already provide additional oil analysis tools that include a particle counter or trending unit with the necessary interfaces into their condition-monitoring (CM) software. Interfacing particle count data or ISO cleanliness codes within CM software can be a precursor to potential problems, which can be solved by advanced oil analysis or vibration analysis. If your supplier's unit does not offer this type of interface, check to be sure the supplier is willing to provide the output data from the instrument so it can be imported into the CM software. Of course, the items listed above require the unit to have a communication port, preferably one easily connected between

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the computer and APC to upload results. While these ports are typically an RS232 style, they limit cable length and require a free serial port (although USB connections have eliminated this problem of sharing with the mouse).

Roll-Off Cleanliness and Process Quality Control

If you need a particle counter to monitor roll-off cleanliness of fluids in new or rebuilt machinery, or for the quality control of process fluids and metal working fluids, then a different set of parameters exists. A portable online unit may be the most convenient because it can be carried to different sites. But because flushing typically requires a turbulent flow hence aerated fluids, then it is likely that the use of light blockage counters online would need care in their use.

For qualification purposes where conformance to a specific particle count is required, the use of a pore blockage device might best be used just for screening during the flushing process to indicate when a sample can be drawn for a microscopic particle count or an optical automatic particle count. Make sure the portable unit is sufficiently portable, rugged and can print out data (or at least store it to upload at a later time). The requirements are similar to a unit used for condition monitoring, but the storing of data is somewhat different. The proprietary programs often provided with a unit are usually sufficient; but if there is a need to store the data elsewhere, make sure output data is available.

In applications such as on test stands and manufacturing rigs for quality control purposes, OEMs often use particle counters to determine if the fluid is sufficiently clean to meet the standards (for instance, to flush cylinder heads or fill sealed-for-life sub-assemblies). This requires a totally automated unit, so control of the instrument by PLC or PC is crucial, and the communication protocol is another important consideration. Given the number of tests these units can deliver in a short time, extended reliability and service intervals are important. On these fully automated systems, either the optical method or the pressure differential-type pore blockage method should work satisfactorily.

It is only after considering all of these factors that a company should decide on the particle counter best suited to its needs. Weigh your options carefully. When selected and used properly, a particle counter is an indispensable tool for assuring roll-off cleanliness and for routine machine condition monitoring. Do not accept the lowest price unit - this decision will soon be regretted if it is not suitable for the task.

Author: Martin Williamson
Noria UK Limited, P O Box 3156, Chester, Cheshire, CH4 7WE,
Tel: 01244 659381
Fax: 01244 679482
email: mwilliamson@noria.co.uk
web site: www.noria.com

About the Author:

Martin Williamson is a graduate Mechanical Engineer and has managed an oil analysis programme in a mining environment, more latterly supported oil analysis products in a wide variety of industries, and is currently managing Noria UK Limited, based in Chester. Noria Corp, the parent company, based in Tulsa, OK is an independent body of experts in all matters lubrication. Noria provides training and consultation globally through their offices in the US, Canada and the UK and Middle East, and through their partners in over ten countries. Noria publishes two journals bi-monthly; Practicing Oil Analysis and Machinery Lubrication, and these are available free on subscription. Their web-site at www.practicingoilanalysis.com is one of the most comprehensive sites for independent lubricant information.

NORIA

RATIONALISATION OF GREASE PACKAGING

SUMMARY

Recommendations are put forward which provide a basis for the future International rationalisation of Grease Packaging in terms of dimensions, fill quantities, shape and package materials.

INTRODUCTION

The idea for a Grease Packaging Working Group was proposed and agreed at the 1996 ELGI AGM. The task given to the Working Group was to "Define an ELGI Standard for a Core Range of Grease Packages". The WG convened the first three years by Mike Morris and followed by Werner Möller held regular meetings in the ELGI office in Amsterdam.

It was important from the outset that the WG encompassed the complete requirements of Grease Packaging. To this end a balanced group of Grease Manufacturers, Pack Producers, Equipment Suppliers and Consultants was put together guaranteeing support from all sides of the Grease Industry.

The wide-ranging task of the WG included as well commercial as suppliers and users points of view. Additionally Market Trends, Environmental and Health and Safety concerns had been considered.

Following segments had been defined to cover the most important issues:

- **Fill Quantity (Pack Size)**
- **Materials**
- **Dimensions (Inner Diameter, Overall Height)**
- **Shape**

Adopting the same specifications for metal and plastic packs would lead to a problem within the package manufacturers of there not being available the requisite moulds. The small market size would not support the creation of new Grease Pack moulds. As a consequence the WG decided that a market survey be carried out. On the basis of this survey the following core range of dimensions have been selected:

Pack Size	Material	Inner Diameter top/bottom (mm)	Overall Height (mm)	Shape
0.4 kg	Plastic	DIN 1283	DIN 1283	DIN 1283
1.0 kg	Tin Plate / Plastic	108 105-155 / NA 145	145 105-145 / NA	Cylindrical Conical
5.0 kg	Tin Plate / Plastic	180 190-255 / NA	255 180-233 / NA	Cylindrical Conical
18.0 kg	Tin Plate / Plastic	286 / 266 305-282 / 293-262	375 424-369/423-367	Cylindrical Conical/Cylindrical
50.0 kg	Black Plate	360	635	Cylindrical
180.0 kg	Steel	EN 209	EN 209	EN 209

- NA = not available
- Different features are available for all mentioned packs in the market.

ELGI - Packaging Working Group
W. Möller, Chairman - Packaging and Lubricant Consultant