Application Note

SpectroLNF Q^{200} – An Improved Wear Particle Analyzer with New Capabilities for Machine and Lubricant Viscosity Condition Monitoring

Abstract

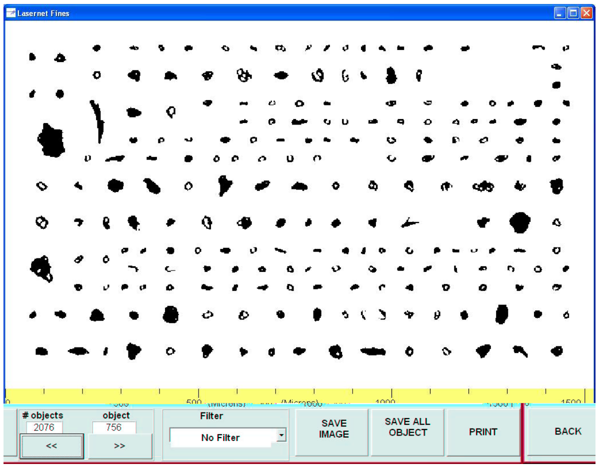
The fundamental premise of machine condition monitoring by wear particle analysis is that an abnormal wear mode causes an increase in the size and concentration of wear particles above a previously defined baseline. LaserNet Fines is the ideal tool to establish dynamic equilibrium concentration and hence set alarm limits for any type of machine. Such limits can be set for the type of wear and according to particle size ranges.

The new and improved Spectro LNF Q^{200} brings additional capabilities to the in-service oil analysis application. In addition to wear particle classification and particle counting, it is capable of performing physical property analyses of oil samples by measuring viscosity, water and soot.

Introduction

In oil analysis, viscosity is one of the most important physical properties of lubricating oil. The application will govern the viscosity required to provide a sufficient film thickness between moving parts of a machine to reduce friction and wear. Change in an oil's viscosity can compromise the film thickness which can lead to excessive wear and subsequent failure of the machine. A positive or negative viscosity change can be an indication that the oil has been contaminated or it has become severely degraded and has reached the end of its useful life. The new SpectroLNF Q^{200} is now able to closely monitor and track machine condition through particle classification and particle counting, but also lubricant condition by measuring viscosity, free water and soot. These analytical tests, when combined together into one instrument, provide a wealth of information on the overall health of a machine and condition of the lubricant.

Machine and Lubricant Monitor – 5 Key Parameters



Over the last decade the LaserNet Fines has been proven to be one of the leading innovations in the world of oil analysis. It has established itself as being the only instrument to provide insight into machine condition through quantification and classification of contaminant particles and wear debris using its unique direct imaging technology. In addition, the laser imaging technology and expert shape recognition has the added benefit of being able to detect and quantify soot and free water contamination in used (in-service) oils.

The next generation of LaserNet Fines, the SpectroLNF Q^{200} now offers improved, faster particle count and wear particle shape classification together with dynamic viscosity measured at 40°C.

This makes it the only instrument in the world that reports these 5 key oil parameters (particle concentration, particle classification, viscosity, water and soot) all in one measurement.

By utilizing the established technology behind its efficient particle counting technique, the SpectroLNF Q^{200} is able to determine dynamic viscosity strictly from first principals using Pouseille's Law. This is something that no other dynamic viscometer on the market has been able to achieve due to the critical design restraints that exist when trying to accurately measure flow in a tight restriction. Consequently, other styles of on-site viscometers that measure dynamic viscosity are frequently calibrated indirectly using other properties in the oil that can lead to errors in the measurement as the oil degrades.

SpectroLNF Q^{200} Dynamic Viscosity Theory - Poiseuille's Law

Poiseuille's equation relates the pressure drop of a fluid flowing across a pipe. The SpectroLNF Q^{200} is the only instrument available that derives dynamic viscosity from its fundamental parameters when applied to flow in a pipe.

The flow cell in the LaserNet Fines provides sufficient restriction to enable the flow rate and the pressure drop to be accurately measured allowing for calibration of dynamic viscosity. The flow of fluid in the center of the cell is laminar which provides the basis for the measurement. The flow rate is measured by calculating the speed of the particles in the fluid which is derived by knowing the time it takes a particle to travel a certain pixel distance on the imager chip. The pulse separation of the laser is able to be accurately controlled to enable optimum separation of particles on the CCD for a wide range of fluids from ISO 15 – ISO 320 grades. To increase accuracy, shape recognition is also utilized to ensure that the same particle is identified in the second pulse at a different location on the chip. The darkness of fluids due to soot loading will have no detrimental effect on the accuracy of the measurement.

$$\Delta P = \frac{8\,\mu\,LQ}{\pi\,r^4}$$

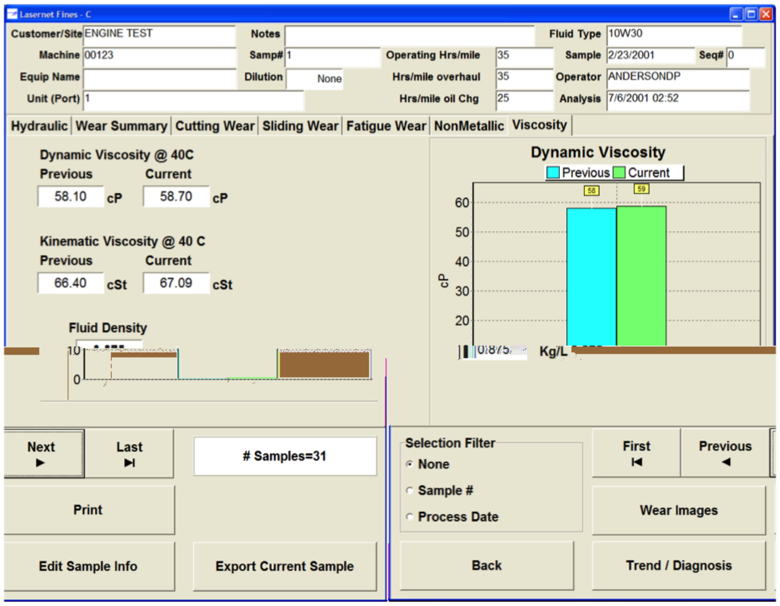
Where:
ΔP is the pressure drop
L is the length of pipe
μ is the dynamic viscosity
Q is the volumetric flow rate
r is the radius
π is the mathematical constant

Performance

Dynamic viscosity is measured at the end of the particle count and shape recognition routine. Viscosity data is reported simultaneously with the particle counts in the final results screen and can be similarly trended.

Item	Performance
Throughput Time	1 to 4 minutes
Accuracy	+/- 3-5%
Repeatability	1-2%
Viscosity Range	ISO 15 to ISO 320

Dynamic (Absolute) Vs Kinematic Viscosity



Viscosity for oil analysis is often measured in laboratories using kinematic capillary tube viscometers that report the ratio of viscous force to inertial force (dynamic viscosity / density). The result is kinematic viscosity reported in Centistokes (cSt). This style of viscometer has traditionally been used for quality control of new lubricants in blending applications where high precision is key.

Kinematic viscometers have found their way into commercial used (in-service) oil laboratories mainly because of their inherent high throughput capabilities, even though in this application, high precision is not required. Care needs to be taken when comparing the two viscosity measurements because the density of a used oil can change along with the viscosity. In this case, the two readings will not correlate and the error between the two measurements will be the resultant change in density of the fluid. The SpectroLNF Q^{200} has the ability to report kinematic viscosity using a density correction in the software that is often assumed from the new oil. Unless the used oil density is known, care must be taken when comparing instrument data that measures kinematic viscosity and absolute dynamic viscosity. It should be understood that both measurements are equally applicable to used oil analysis when trending is used to determine an oil's condition.

The Importance of Measuring Viscosity at 40°C

Dynamic viscosity on the SpectroLNF Q^{200} is reported at 40°C to within the published accuracy specifications. The SpecrtroLNF Q^{200} features a newly designed flow cell that is fitted with a thermocouple that is mounted inside the fluid path close to the measuring window. The oil is heated in the flow path just before it enters the cell by a pulse modulated heater that maintains constant temperature at the pre-configured set point thus ensuring accurate results.

Measuring fluid viscosity at or close to published limit data at 40°C is very important because the viscosity index (VI) of fluids can vary considerably depending on the application, and one VI number alone cannot be relied upon to extrapolate viscosity to 40°C from room temperature. The VI improvers in the oil also get depleted as the oil degrades, therefore relying on an extrapolation in this way is not recommended even if the VI is known .

Conclusion

The LaserNet Fines has been a powerful used oil analytical tool since it was first introduced. Its capability to classify particle shapes into wear modes, while also performing particle counts made it unique in the industry. Since then, the additional capability of the SpectroLNF Q^{200} to also determine lubricant condition based on water, soot and viscosity has made it an indispensable tool in the machine condition monitoring through used oil analysis application.