Fluid Condition Sensor Technology Reduces Costs and Downtime

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Currently lubricant analysis primarily takes place in laboratories. The wide variety of analytical tests, strengthened by their unmatched accuracy and precision, makes lab-based oil analysis an integral part of any serious preventive maintenance program.

However, several factors are driving an increasing demand for real-time, on-site lubricant health monitoring:

- A desire to extend oil drain intervals for economic and environmental reasons. Today, lubricants are replaced and replenished based on rules of thumb and on hours of usage. As a result of not taking the true condition of the lubricant into consideration, they are replaced either prematurely (incurring unnecessary costs) or are replaced too late, thereby risking the overall health of equipment.

- Reduction of warranty costs by original equipment manufacturers (OEM). By virtue of not knowing the true condition of lubricants, machine operators may inadvertently cause mechanical failure in equipment, which otherwise would have functioned without any issue. When this occurs within the warranty period, it is not uncommon for the OEM to bear the cost of repairing or replacing equipment.

- The end user's quest to gain a competitive advantage by minimizing downtime and the associated opportunity and repair costs.

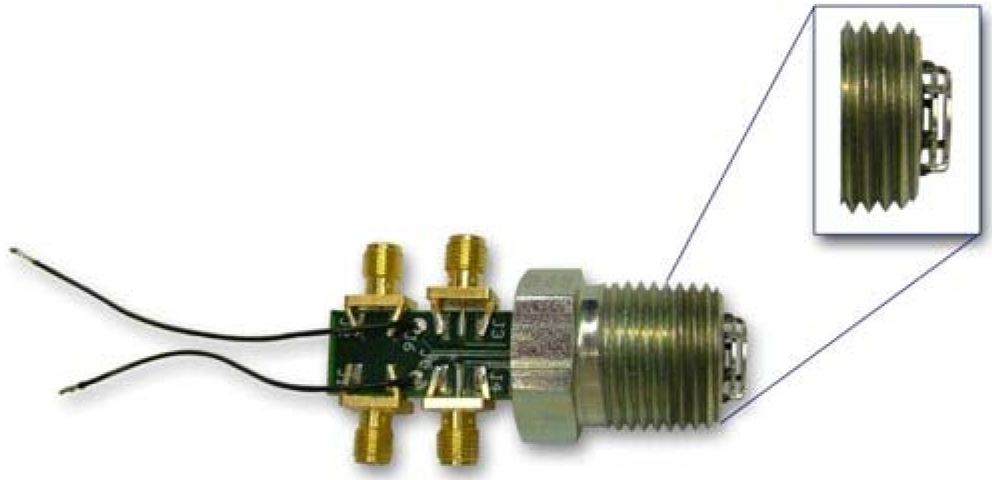
Fluid condition sensors, which provide the ability to continuously monitor the health of lubricants, address the need for extended oil drain intervals, reduce OEM warranty costs and improve the overall equipment availability for the end-user.

Fluid condition sensors cannot replace lab-based oil analysis. Rather, they provide a means to more judiciously make use of detailed lab analysis only when further investigation of lubricant health is warranted. Fluid condition sensors provide equipment operators with the information necessary to make decisions on when to send samples to a lab as opposed to using arbitrary and sometimes artificial timetables. Usually, this is less frequent than originally envisaged, although sometimes it may be more frequent.

Further, a fluid condition sensor can provide timely information on rapidly deteriorating machine conditions on a continuous, real-time basis, something that lab-based analysis cannot provide. By using such sensors to complement and augment lab-based lubricant analysis programs, the end-user can improve efficiency, prevent damage and lower costs.

Fluid Condition Sensor Technology
Viscosity, conductivity and dielectric constant are primary indicators of overall lubricant condition. The technology to monitor these metrics in situ either already exists or is actively being developed by companies in the fluid condition sensors arena. The conductivity and dielectric constant of a fluid can be

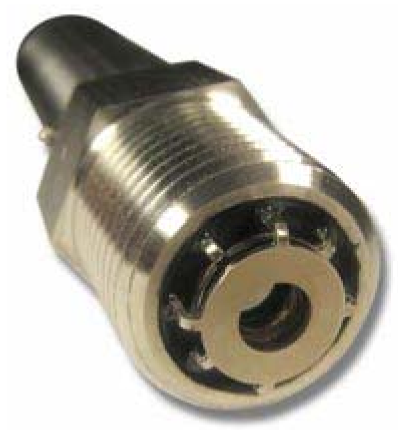
quantified by using a parallel plate capacitance cell arrangement, as shown in Figure 1.



Measuring the admittance of the cell at a reasonably low excitation frequency ensures that the dielectric loss is negligible. In this case, the conductance of the cell will directly be related to the conductivity of the fluid, while the susceptance of the cell will directly be related to the “static” relative dielectric constant of the fluid. Changes in fluid condition (i.e. water ingress, soot loading and presence of metal particles) will result in observable changes in the conductivity and dielectric parameters, and when combined with viscosity measurement, can be used to ascertain overall fluid health.

Viscosity can be measured by placing a piezoelectric thickness shear mode (TSM) resonator (sensing element) in contact with the fluid. The top surface of the sensing element interacts with the fluid forming a thin fluid layer (on the order of microns) that moves with the vibrating surface. The fluid’s viscosity determines the thickness of the fluid layer that is hydro-dynamically coupled to the surface of the resonator. The sensing element resonates in uniform shear motion at frequency $\omega=2pf$ with an amplitude U. The frequency is known by design and the amplitude is determined by the level of the electrical signal applied to the sensing element. The shear wave penetrates into adjacent fluid to a depth d, determined by the frequency, viscosity and density of the liquid as $d=(2h/wr))^{1/2}$, where h is viscosity, w frequency and r is density. The shear wave interaction with the fluid changes with changes in viscosity and density, which can be measured by the electrical properties of the piezoelectric sensing element.

No single fluid metric, by itself, is sufficient to provide an accurate assessment of lubricant health. Viscosity, conductivity and dielectric constant by themselves provide only part assessments of fluid condition. However, a combination of some or all of these metrics can provide highly informative signs of overall lubricant health. For some lubricants, viscosity and dielectric constant can prove to be highly relevant. For others, a combination of viscosity, conductivity and dielectric constant can prove to be ideal.



Fluid condition sensors, which can track a variety of fluid condition metrics, including viscosity, conductivity and dielectric constant, provide the continuous monitoring capability required to ensure the uninterrupted operation of equipment. However, not all of these metrics will necessarily apply to every application. In addition to the long-term benefits of real-time monitoring, further cost savings can be found by using sensors that provide the flexibility to track only those metrics that are most relevant, rather than using a one size fits all solution.

About the authors:

Shravan Jumani is the product manager for SenGenuity, a division of Vectron International, and Ray Haskell is the director of engineering. SenGenuity is a leading provider of breakthrough sensor solutions for performance and reliability in critical data gathering applications. Coupling its state-of-the art precision sensor solutions with Vectron's surface and bulk acoustic wave (SAW and BAW) technology, SenGenuity delivers innovative solutions for measuring the condition of fluids in challenging, embedded environments, and is driving the development of breakthrough solutions for gas and physical sensing applications. For more information, visit www.sengenuity.comor call 888-328-7661.