VISCOSITY – Value of Interest

Oil is often considered to be the vital line of a machine or engine and can give crucial insight to its health. From all the important data discerned from oil, viscosity is considered to be the most important single physical value, and therefore, a special value of interest.

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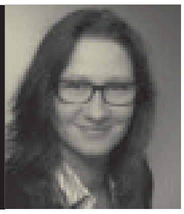

CONDITION MONITORING (CM) is on everyone's lips and a big talking point for industries. A fast growing business offers different approaches towards stepping back from reactive and preventive and instead turning towards proactive maintenance, keeping a close watch on machinery and processes of interest. Nowadays, condition monitoring is applied in many industries and is a huge business for the suppliers and consultants involved. CM is a synonym for monitoring several parameters, like temperature, vibration or oil status, of any machinery to assess its condition. Thereby, it is a crucial part of **preventive** maintenance.

Historically, maintenance and exchange intervals for industrial assets has been **proactive**, meaning calendar or time-based. Recommendations for any maintenance or repairs are usually very conservative to ensure assets come to no harm.

However, this approach still has its advantages with regards to **reactive** maintenance, which is carried when failure has already happened. This not only means broken parts, but also unscheduled shutdown for repair or even worse, longer downtime until spare parts are available.

CM-based preventative maintenance builds actions on the condition of a machine at the present moment. It helps to avoid repairs, but also minimizes downtime and prolongs the life cycle of components. This not only has a huge impact on the economic efficiency of a company by saving money for resources, but also has a positive influence on ecological aspects.

Oil Analysis

Oil analysis is a substantial part of CM in many industries. The tasks of lubrication in assets range from wear protection and decreased abrasion over cooling, corrosion prevention, sealing and neutralization of combustion products up to keeping an engine clean. Given these tasks it is no surprise that undetected changes in lubrication and oil properties cause problems ranging from loss of performance right up to failure and damage of the complete machinery.

As summarized in the TLT magazine [1], if used correctly, oil analysis can among other things:

- Increase equipment reliability.
- Reduce overall maintenance expense.
- Pinpoint abnormal conditions and wear trends.
- Streamline maintenance procedures.
- Identify human error and neglect.

A well-established method of oil analysis is the use of specialized and independent laboratories. They are a great resource for a plethora of information about oil quality and the most accurate way to get information not only about one performance attribute, but many. Test procedures are standardized, comparable and reliable and usually, well-educated engineers give assessments not only on the condition of the oil itself, but also on the condition of the machinery. However, the time between taking a sample and getting the results is usually 24–48 hours. Even worse, months can pass between oil samples being taken and during this time the condition of the oil is unknown.

To the contrary, online sensors give continuous and instantaneous feedback of oil attributes and, therefore, can raise the alarm very early potentially avoiding catastrophic failure. They are more in common use and technology gets more sophisticated and elaborate. Sensors can be adapted and housed in machinery and can record data during their operating conditions while eliminating the risk of having personnel near to potentially dangerous equipment. Furthermore, due to long term recording of data it not only gives a snapshot of condition, but enables a vital trend analysis.

On the downside, online oil sensors are still only able to provide information on a small number of attributes and a single sensor can never show the whole picture. Sensors are therefore most useful when used in conjunction with lab analysis. While a sensor gives indication of an issue at an early stage, lab analysis is probably able to verify the root cause, which can be counteracted and fixed right away.

Viscosity

There are many important attributes to assess lubrication quality in its entirety. For instance, elemental analysis gives good indication of wear particles, impurities and remaining additive elements, whereby an IR spectrum analyzer points towards oxidation, nitration and liquid contaminates.

However, viscosity is recognized as the most important single physical attribute of any oil or lubricant. The general definition of viscosity is a *fluid's resistance to flow*, which means high viscous fluids are sullen, honey as an example, while low viscous fluids like water are rapidly flowing.

In terms of oils the viscosity makes significant contributions to the ability of hydrodynamic lubrication. There are two forms: **dynamic** and **kinematic** viscosity. Dynamic viscosity is named the real physical viscosity as it considers the relation between shear stress to shear rate, whereby more common is kinematic viscosity, which is physically viewed as the viscosity-density-relation. Kinematic viscosity is easier to measure and it is basically standard for oils and lubricants to state kinematic viscosity and viscosity grades at either 40 °C or 100 °C or both.

These two temperatures indicate the high dependency of viscosity on temperature. Therefore, when choosing suitable oil the operating as well as the maximum temperatures in non-operating state must be taken into consideration. To improve the viscosity-temperature behaviour, nowadays Viscosity Index (VI) improver additives are common – these ensure sufficient lubrication manner at high as well as low temperatures.

Generally, if viscosity is too low, the aggravated risk exists of a too thin lubrication film leading to excessive wear and a shortened lifetime of components. Vice versa; too high viscosity can limit the ability of the oil to get to all places to be lubricated

Preventative maintenance builds actions on the condition of a machine.

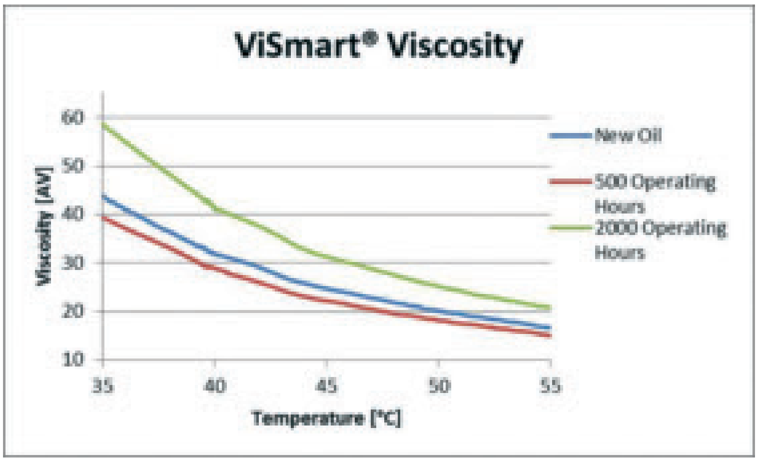

Fig.1. Viscosity change due to aging.

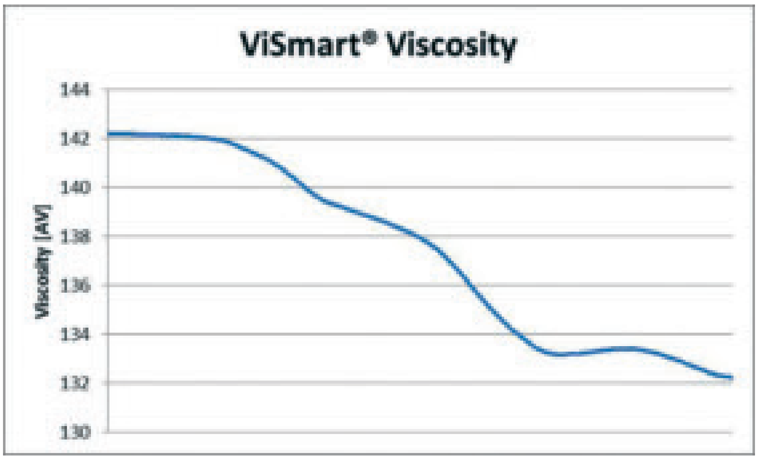

Fig.2. Viscosity change due to contamination (ISO VG46 with VG32).

leading to a lack of lubrication, which consequently leads to higher friction and also, increased energy consumption.

There are several reasons why viscosity can change over time, and some even offset each other. Although many changes of viscosity are consequences of aging and wear, some are due to influences from outside. Depending on the severity and reason for a viscosity change, measures can be taken to refresh and prolong the lifetime of a lubricant in use.

All lubricants are exposed to inescapable aging, which leads to a change in viscosity. But aging is accelerated by several influences, most common are contact with oxygen and temperature (Fig.1).

Oxidation leads to an increase in viscosity and is accelerated by temperature. A rough-and-ready rule for mineral oil says that for every 10°C the temperature increases, oxidation doubles and the time to the next necessary oil change is halved. Therefore, attempts go towards as low temperatures as possible. Oxidation is indicated by brown coloured oil.

If oil gets too hot, there is talk of **hydrocracking** or **thermal decomposition**: the oil molecules get destroyed – the oil gets black. Whilst this leads to a decrease in viscosity, the decrease in engines will most likely not be recognized as at the same time soot will emerge, leading to a viscosity increase. However, viscosity decrease due to hydrocracking could be realized for example by heat transfer oil.

As mentioned, many oils get VI improver to change the oil's behaviour on one or the other end of the temp-visc curve. With the **reduction of VI improver additives** the viscosity behaviour changes back to the origin of the base oil.

Oil is doing its job when it takes care of lubrication between components. However, at the contact point oil is exposed to mechanical stress: **shear**. This cuts down the molecular chains of oil, which will lead over time to a decrease in viscosity.

Liquid contaminants in oil are known to alter viscosity and can cause damage to components of assets. Exemplary, the presence of residual cleaning solvents and fuel contamination can cause seals to swell and create less than ideal engine operating situations.

With regards to engines, there will always be some amount of **fuel ingress** to the oil. Usually, it is vaporized during operation, at least at longer operating times when the engine gets hot. Only fuel with a high flashpoint is more resistant to vaporization, Biodiesel as an example. As fuel has a lower viscosity than oil ingress leads to lowering of viscosity. For gasoline engines already 1 percent fuel ingress can be critical whereby, for diesel engines values of >3 percent are usually still okay.

In off road vehicles and some machinery there is antifreeze in proximity to oil reservoirs. If, due to leaking seals or any other reason, antifreeze ends up in the oil it could cause bad damage. It leads to an increase in viscosity and even worse, when detergents of oil react with **antifreeze** so called oil balls, which are close to solid lumps, might emerge and generate damage.

Another common reason for viscosity change is the **mixture with other oil** (Fig.2). If not taking care, a low oil level might be refilled with oil from a wrong canister or a gearbox is rinsed with other graded viscosity oil than the one it should use in operation. This can cause huge and fast damage to components or complete machinery.

VISCOSITY IS not only the most important property of a lubricant; it is also influenced by many other aspects and therefore, should be monitored very carefully. Condition monitoring of industrial machinery, which can include in-situ viscosity measurement of lubrication oil, is becoming more and more common-place and can reduce maintenance costs, increase reliability and increase machine uptime. However, knowing only the viscosity value without the ability to interpret and see the whole picture will result in it only being a number. ■

References
(1) J. Van Rensselar, 'Used-oil analysis for predictive maintenance', TLT-Tribology & Lubrication Technology, May 2015, p.45-46

(2) General information by huge knowledge and database of OilCheck Company; Oil Analysis Laboratory located in Brannenburg, Germany.

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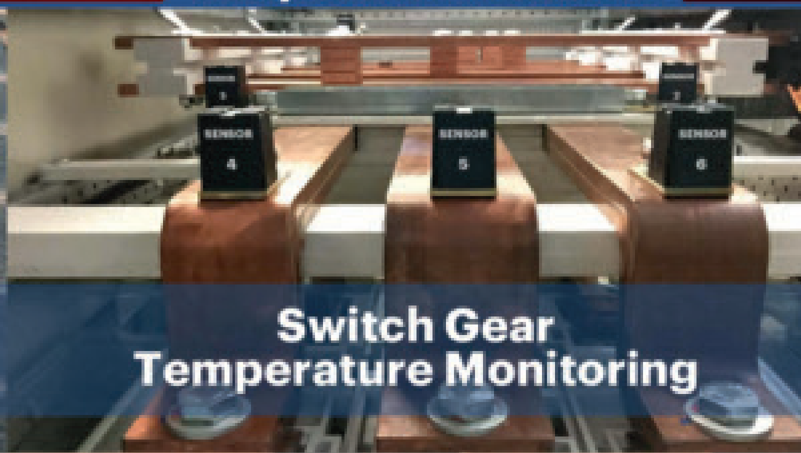

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Applications

- Smart Sensors for Smart Maintenance
- Condition Based Maintenance
- Predictive Maintenance
- Machine Condition Monitoring

ViSmart® Sensor Benefits

- Real time, continuous oil viscosity and temperature readings
- Oil condition monitoring for asset health and longevity
- Contamination detection (e.g. water, fuels, and solvents)
- Trending of lubricant quality

TempTrackr® Sensor Benefits

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- Easy to mount in restricted access areas

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