Kinematic viscosity – The key to lubricant analysis

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When talking about lubricants, independent of the origin or the technical purpose of use, viscosity is considered the most important physical property. Viscosity is the measure of internal friction of a liquid or in other words, the resistance to flow at a specific temperature. For technical reasons, but also during the purchasing process viscosity classes play a significant role. Industrial lubricants for instance are identified by their ISO viscosity grades. An ISO VG 46 has a nominal kinematic viscosity of 46 mm^2/s at 40°C with a typical tolerance of +-10%. When an engineer speaks of an "SN 100", this means a mineral base oil with a kinematic viscosity of 100 mm^2/s at 40°C. The specification of the kinematic viscosity is therefore expected by professionals in the industry.

"Differential pressure capillary method" – The new high potential method

Because viscosity is such a fundamental and widely used property, there are numerous different viscosity measurement devices available on the market. Most of the devices use the so-called glass-capillary method which is considered to be the classic approach according to the standard ASTM D445.

Using a similar principle, Z-shaped capillaries are also often used. These are also known as "Houillon" viscometers according to ASTM D7279. The fundamental measure is actually the time it takes for a specified volume to flow out of the capillary pulled by the gravimetry. Therefore, kinematic viscosity is derived because the resulting viscosity is also influenced by the mass of the sample.

A different approach is using a rotational measurement principle leading at first to the dynamic viscosity. This measurement principle is named "the Stabinger principle" after his inventor and works according to the method ASTM D7042. Due to an attached density tube the sample density is also determined at the measurement temperature which is the linking factor between dynamic and kinematic viscosity.

Recently, a newly developed technique was introduced, that also contains a capillary, but the driving force is a small differential pressure which pushes the sample out. This innovative new method has been made possible because of the precise and high-resolution determination of the pressure drop over time and can best be summariwed as "differential pressure capillary method". This physical principle results in both the kinematic and the dynamic viscosity. In extension to the viscosities an independent density cell is connected in parallel.

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Besides delivering a 5-digit density value at an individual temperature between 15°C to 100°C, it is used to optimise the measured precision of the kinematic viscosity. This possibility arises from the fact that current measurements lead to an overdetermined parameter set that can be used for this optimisation.

The techniques described above can be categorised as representative examples of precise and automated viscometers. All principles lead to specific pros and cons.

The new kinematic viscometer ERAVISC X, is the first device on the market based on this novel differential pressure capillary method.

Typical requirements by professionals are highest measurement precision, but also flexibility when it comes to measurement temperature and suitability for different products. The following table summarises the most important properties in a simplified manner:

	Differential pressure capillary	Glass capillary	Houillon (S-flow capillary)	Stabinger principle
Standard	ongoing	ASTM D445	ASTM D7279	ASTM D7042
Fundamental measured properties	Kinematic & dynamic viscosity & density	Kinematic viscosity	Kinematic viscosity	Dynamic viscosity & density
Precision	High	Highest	Moderate	High
Flexible measurement temperature	Yes	No	No	Yes
Measurement speed	High	Moderate	Highest	High
Combined density	Yes	No	No	Yes
Sample volume	Low	Moderate	Lowest	Low

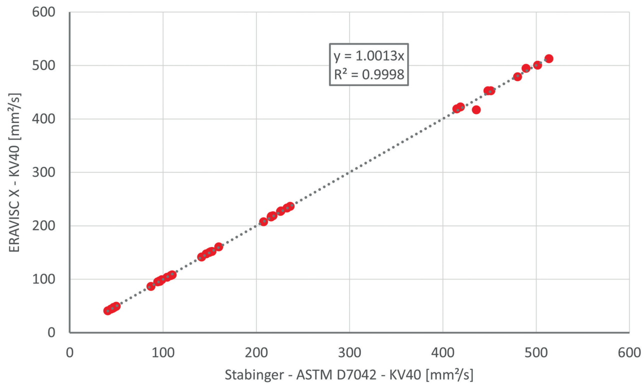
Comparison study shows excellent correlation

When new measurement methods are offered, questions understandably arise regarding measurement precision and comparability with existing methods. For this reason, a comparability study was carried out together with an independent research institute and an industry partner. In this study a total of 42 representative oil samples were compared. There was a mix of gear oils, engine oils and hydraulic fluids both mineral oil and ester based with a maximum kinematic viscosity at 40°C up to 500 mm²/s. The sample matrix was built up of fresh oil samples, in-service oils and artificially aged oil samples.

The following chart shows the correlation between kinematic viscosities at 40°C measured with the ERAVISC X versus results measured according to ASTM D7042. The comparability of the measurement results is clearly given with a maximum statistical difference of 1.2 %, whereas the average absolute difference is only 0.4 %. If you compare these figures with typical reproducibility according to current standards, there is certainly positive confirmation.

Conclusion

In the field of lubricant viscometry there are various measurement technologies available. Most of them deliver highly precise results but are inflexible when it comes to measurements at changing measurement temperatures. The ERAVISC X viscometer uses a new technical approach, the "differential pressure capillary method", to combine the advantages of established methods for direct and highly accurate measurement of kinematic viscosity. Laboratories now have a modern alternative for flexible viscosity and density analysis for base oils and lubricants.



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