Comprehensive Study of Capillary Viscosity & Recent Improvement in ASTM D445 Techniques for Petroleum & Petrochemical Products

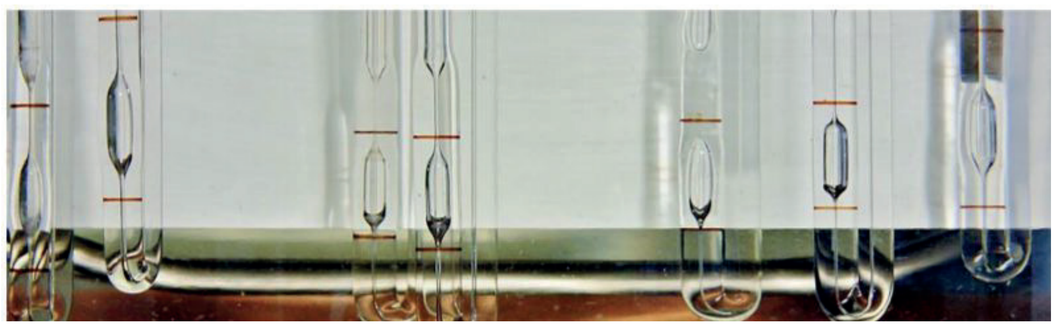
Karandeep Singh, Raj Shah, Nathan Aragon

Introduction

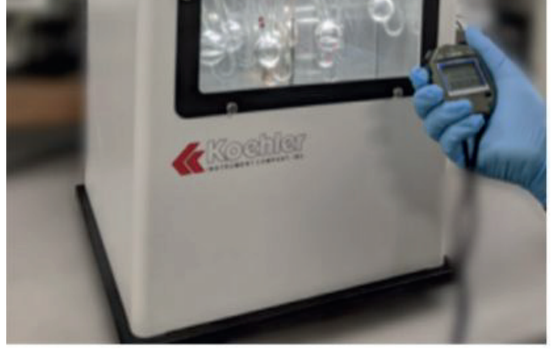
Viscosity is a measurement of a fluid's internal friction, or put more simply, how little or how much a fluid flows. This concept, while seemingly simple, is a very complex and important idea to consider in many fields, especially when making petroleum products. The viscosity of a fluid greatly affects its physical properties and so determining the viscosity of a fluid would help in determining its physical properties. This is especially important when it comes to petroleum products as they are used in many different fields and play a huge role in our daily lives. Determining the viscosity of a fluid would allow researchers to figure out how useful a fluid actually is and whether or not they can improve it. This poster will talk about how the viscosity of fluids is determined, why the viscosity of a fluid is important, and how it affects petroleum products.

How Viscosity is Determined

There are 2 types of viscosities: dynamic viscosity and kinematic viscosity. Dynamic viscosity is the amount of shear stress, which is the amount of force per unit area, a fluid can take before it deforms. Kinematic viscosity is how much a fluid resists flow due to gravity. There are different standardized tests for each type of viscosity but this poster will be focusing primarily on kinematic viscosity and one of the most common tests for it, ASTM D445. It consists of placing the fluids that need to be tested in a capillary viscometer inside a viscosity bath and allowing it flow until it reaches a certain point.



Moir, Michael. "Improving ASTM D445, the Manual Viscosity Test, by Video Recording." Journal of Testing and Evaluation, vol. 47, no. 1, American Society for Testing and Materials, 2019, doi:10.1520/JTE20170341.

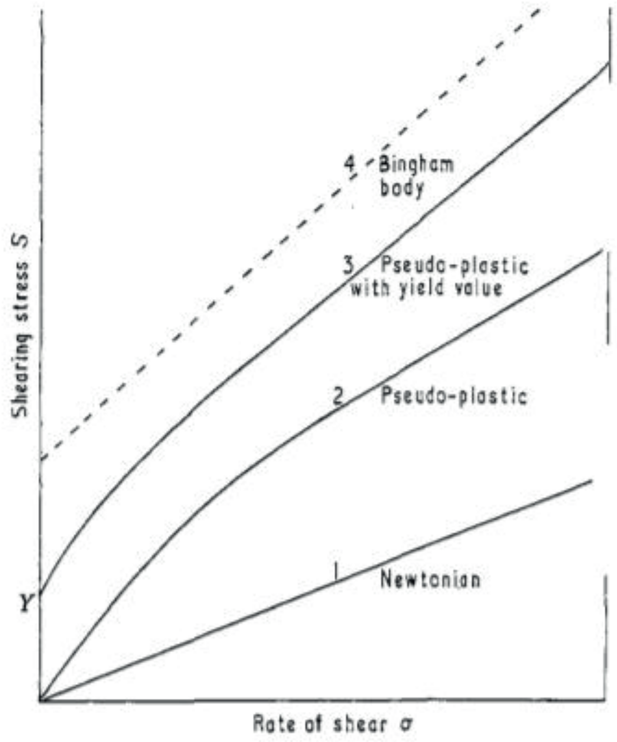


News, Petro Industry. "Applications, Tests, and Measures of Viscosity Loss in Shear Stability of Multi-Grade, Polymer-Thickened Lubricants." Petro Online, 20 Nov. 2020, www.petro-online.com/article/measurement-and-testing/14/koehler-instrument-company/applications-tests-and-measures-of-viscosity-loss-in-shear-stability-of-multi-grade-polymer-thickened-lubricants/2850.

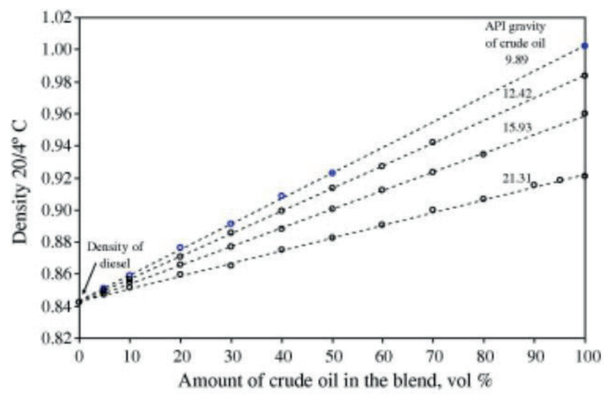
On the left is Koehler Instrument's K23900 Kinematic Viscosity Bath. This device conforms to the most recent ASTM D445 standards and allows one to easily find and measure the kinematic viscosity in a controlled environment. The viscosity of fluids greatly depends on the environment they are in, most importantly the temperature. This viscosity bath keeps the samples in a controlled environment at a constant temperature and with a range that is customizable so that samples may be tested at various temperatures. This is especially useful because most samples and fluids do not stay in controlled conditions and are usually subject to changing temperatures and conditions so it is important to know their viscosity in these different conditions. The viscosity bath comes equipped with 7 capillary viscometers so it makes it simple to view samples side by side which allows one to easily compare them and quicker tests.

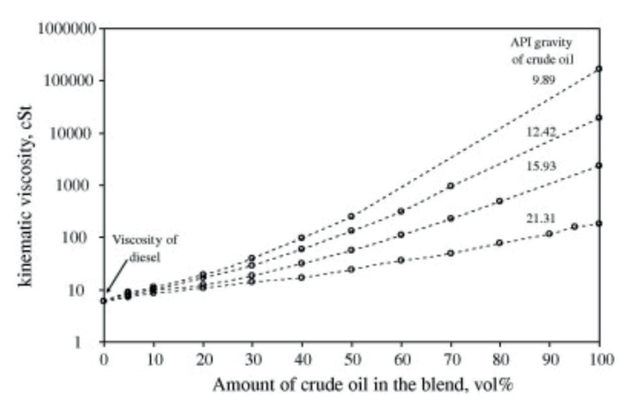
Changes to ASTM D445

In 2019 ASTM D445 was changed to better suit new ways to run tests. The changes mostly focus around temperature measuring devices. The most notable changes to the test method are the changes to requirements for digital thermometers. The main changes to these requirements had to do with was how the temperature calibration data should be collected in different temperature ranges and how it should be in the reports. It also has a focus on the placement of the thermometers on the bath and specifies how much the thermometers should be immersed and how exactly they should be placed. They also specify how much the maximum amount of "drift" a digital thermometer can have. These changes help to standardize temperature measurements and lead to more accurate data.



General shear rates of different non-Newtonian fluids
Davenport, T. C. "Viscosity in the petroleum industry." Physics Education 3.3 (1968): 139.





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Centeno, Guillermo, et al. "Testing various mixing rules for calculation of viscosity of petroleum blends." Fuel 90.12 (2011): 3561-3570.

Conclusion

Viscosity is an important characteristic as it affects the physical properties of fluids in various ways. While viscosity is often overlooked, it is a trait that is very essential to the optimization of many different products in our daily lives, such as petroleum products which impact heavy equipment and machinery that may be used in the form of a car or a truck or in a factory. Hence, it is extremely crucial to be able to accurately determine what the viscosity of a fluid is in order to accurately predict how a fluid will act in certain conditions and how it could be improved.

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