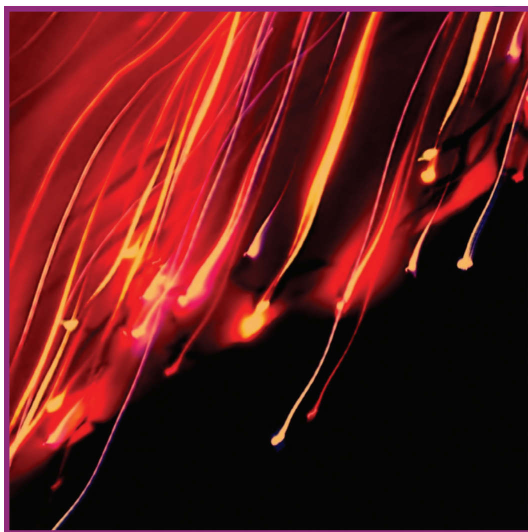

Viscosity Control and Petroleum-related Operations

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Petroleum is one of the most important fluids in today's global marketplace; it remains the primary source of liquid fuels and of rough material for polymerisation industry's product manufacturing. Viscosity is an important fluid characteristic for many reasons: it can be a functional property; it can be correlated to an exclusive attribute; it can be related to utilisation efficiency; or viscosity can be one indication of how a fluid is handled (pumped, filtered, stirred, etc.). Like most physical properties, viscosity is measured with laboratory analysers or directly in-line. This article aims to provide insight into viscosity as it relates to petroleum-related operations.

Drilling mud

While drilling natural gas or oil wells, a fluid called "drilling mud" facilitates the creation of boreholes into the earth. In general, there are two types of mud: water-based and non-aqueous. Various ingredients such as water, gas, chemical solvents, or polymers comprise the formula. Each drilling fluid is chosen by evaluating several concerns and blending is usually done on-site prior to injection in order to adapt the mud's composition to the drilling environment.

Drilling mud is an important element that provides hydrostatic pressure to maintain stability in the wellbore, it cools the drilling head to prevent damage, lubricates tubing and down-hole tools to minimise corrosion, and it minimises formation damage by transporting and evacuating cuttings to the surface. Controlling viscosity and shear rate optimises drilling mud properties and is valuable in terms of location, depth, pressure, geologic properties, and extracted materials. In addition, continuous in-line viscosity measurement at both the entry and exit of the drilling mud keeps fluids inside the well under control, thus preventing injury to both man and environment. The instrumentation used in this process needs to be rugged and resistant to high pressures and high temperatures, as well as reliable even when particles are present.

Yield increase	From 1 to 10%
Consumption increase	From 1 to 10%
Maintenance reduction	By 10
Un-burned residues	Divided by 7
Smokes temperature	Reduction from 240°C to 200°C
Combustion parameter stabilisation	1%

Table 1: Performance increase in burning operations

Extraction

Extraction presents many opportunities for in-line viscosity measurement. Initial recovery focuses on the immediate identification of the pumped product. Well operators monitor viscosity ranges and determine if the product is oil, gas, water, or a mix between the components. The process can be continuously observed and adjusted according to the materials extracted.

Over time, natural well pressure decreases and flow diminishes. In secondary recovery, pressure in the reservoir must be artificially increased in order to preserve fluidity and maintain extraction. In order to supply additional pressure, pseudo-plastic fluids are mixed according to the subterranean environment and injected into the bottom of the well. While these solutions can be made of natural gas, a water / polymer mix, or gas, both viscosity and shear rate must be controlled in order to improve extraction.

When injection no longer provides adequate pressure, thermally enhanced methods heat the oil. At times surfactants are used to alter surface tension between the oil and water within the reservoir. In other situations, microbial blends break down the oil's hydrocarbon chain. Each method mobilises the oil and brings it to the surface. Throughout each phase of extraction, viscosity control is a key factor in maximising the amount of recoverable oil and securing the good working of the pumping process. The viscosity related instruments used in the extraction process need to be robust and highly resistant to pressure and temperature.

Transport

Pipelines serve various purposes and are commonly classified into three categories. Gathering pipelines are small, interconnected lines that carry crude oil from nearby wells to a processing facility or a treatment plant. Transportation pipelines are huge, over-land networks that transport valuable quantities of oil and its derivative products between cities and countries. Distribution pipelines with smaller diameters move products to tanks, storage facilities or the end-user.

Multi-product pipelines transport two or more different products in sequence within the same line. In this scenario, rarely is there a physical barrier between the products.

Instrumentation, data processing, and communication systems are required to support the intricate pipeline structure. Most of these field devices are installed along the lines in key locations such as injection, compressor, pump, block valve, or delivery stations.

Pipeline companies face the challenge of determining product volume according to flow. Viscosity control enhances pipeline transport: viscosity measurement corrects errors by improving the accuracy of the flow rate measure and reflects actual pumped volume. With ever-fluctuating barrel prices, volume precision is crucial. Implementing viscosity control in conjunction with existing field devices optimises valuable assets, with a significant gain in flow measurement precision. In this precise counting operation, the instrumentation needs to prove excellent repeatability in its results, reliability, with no maintenance requirements.

Refining

The first step in refining is separating crude oil into distinct parts by distillation. The separated parts undergo processing, such as cracking, reforming, alkylation, polymerisation, and isomerisation. Blending consists of stocking the residues (heavy fuel, low added value products) by mixing or adding solvents, thereby transforming them into higher value products. Viscosity control allows for precise blending operations where, for example, in the marine industry, maximum residue and minimum product values are required. Refining consists of complex procedures that produce consumable goods such as bitumen, lubricants, heating oil, diesel, and aviation fuels. Each final product is characterised by specific properties, one of which is the viscosity value.

The viscosity index, according to ASTM D2270-04, is a widely used and accepted laboratory measure of viscosity variation due to temperature changes of a petroleum product between 40 and 100°C. A higher viscosity index indicates a smaller decrease in viscosity with increasing temperature of the lubricant. There are three ways to measure viscosity in refining processes: with a single viscometer, with interpolated dual viscometers, and with a viscosity analyser.

With a single viscometer, a temperature compensation model is applied. The instrument continuously measures the viscosity at process temperature and a processor calculates the viscosity at reference temperature (with variation law). When the difference between process and reference temperature is reduced to ±20°C, a compensation model is implemented. For known petroleum products and increased differences between process and reference temperature (e.g. 150°C), the ASTM D341 model is used. This implies that the reference product and its behavior must be known. This technique satisfies basic viscosity measurement requirements and presents several advantages like minimal front-end investment, instantaneous and continuous measurement, and extremely good reliability.

With two interpolated viscometers, viscosity measurement exists at two temperatures; one measurement is before the reference temperature, the other measurement is after. According to the end user's reference temperature and identified parameters, a processor continuously calculates the viscosity according to the ASTM D341 model. Interpolated viscometers provide reliability with continuous viscosity measurement calculations. Like single viscometer use, this solution satisfies viscosity standards requirements.

The analyser method is the best method for controlling petroleum's viscosity because viscosity is really measured at the reference temperature. With this viscosity principle, a sample is taken from the process and introduced to the analyser. The sample is prepared for measurement, viscosity at reference temperature is memorised, and the sample returned to the process. This procedure is repeated and the sample is continuously renewed. The analyser presents a supreme advantage as the measurement is made at the actual reference temperature, regardless of the product's behavior. With the analyser, any effect of variable process temperature is eliminated. The correlation to ASTM standard is done directly, and accuracy is induced by the measuring principle as opposed to calculation approximation.

For single and dual viscometer applications, the viscosity will vary with product quality and temperature. For the analyser at reference temperature, a real viscosity measurement is made with constant reference temperature, whether higher or lower than the process temperature.

According to ASTM D445, inline measurement must be repeatable, simple to use and install, and require minimum maintenance in both time and cost. The instruments require ex-proof agreement to easily fit in every place of the refinery. Viscosity remains relevant to refining during mixing, blending, and separation operations. Viscosity is a quality control parameter and can be scrutinised in all phases. Superior quality for petroleum products and all its derivatives is dependent upon viscosity characteristics.

Burning

Many liquid fuels are used in the industry, with diesel and heavy fuel oils being the most common. Liquid fuels are used in boilers, burners, furnaces or engines in order to supply heat or mechanical energy. In each case, the burner introduces a spray into the combustion process. From simple to complex combustion formulas, it is known that acting on the viscosity interferes on the droplet size. By adjusting a spray's droplet size to suit the application, a process viscometer in a combustion installation optimises energy production and reduces consumption. In addition, it reduces the un-burned residue as well as dirt accumulation in the combustion chamber and will allow avoiding corrosion. With its reliable and repeatable measure, the process viscometer also provides combustion efficiency. Maintenance, cleaning requirements, and atmospheric emissions are reduced.

In order to obtain superior operation in heavy fuel n°2 burners, the fuel spray must present defined characteristics linked to its viscosity. Those characteristics are provided by the burner manufacturer, and are reached while heating the fuel. Efficiency of the burner is optimum when viscosity of the fluid matches the specifications of the burner manufacturer. Installing a viscosity control system ensures the viscosity value reading and constant viscosity control. Controller interacts on the heater command, and determines the heating energy needed to maintain good heavy fuel viscosity.

In the past, temperature controls combined with viscosity and temperature charts were used because it was simple, and were efficient when heavy fuels had constant characteristics. This is no longer acceptable today as the relationship between viscosity and heavy fuel temperature presents higher dispersions due to the diverse origins of raw oils, different refining methods, and variations among additives. Temperature control alone does not guarantee permanent viscosity stability, as there is too much variation between the products and batches.

With petroleum products, viscosity is even more crucial, as it is a dedicated, burned energy source. Viscosity control is indispensable in the burning of heavy fuels in industrial motors, heaters, and marine engines. Viscosity control inside combustion engines is increasingly realised, measuring and improving power ratio. Refineries, power plants, and utility companies use burners, and manufacturers of burners and engines demand optimal viscosity value to improve their performance rates.

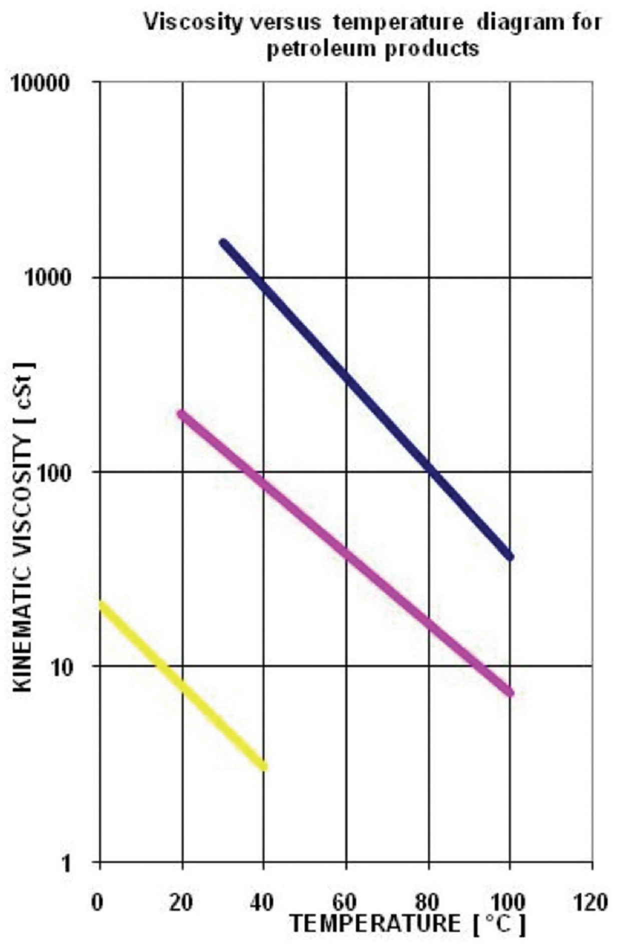

Figure 2: Viscosity vs temperature diagram for petroleum products

Quality control

In petroleum operations, as in many industrial sectors, on-site control is of primary importance in regards to product delivery. Viscosity is a parameter that allows limiting the difference between the refineries ordered product and the effective delivered product.

Viscosity is also a point of security in distribution tanks. Instruments used for this measure need a very good repeatability and reliability. By checking viscosity, companies validate that tanks are supplied with the correct product. By verifying this step, potential mistakes with customers are avoided.

Conclusion

Petroleum-related operations present diverse applications. Viscosity is a key parameter in each phase, allowing or blocking production. In the petroleum industry, prices and volumes are huge; any viscosity related improvements are significant. This is why the global petroleum-related industry needs to pursue its investments in viscosity measurement, focusing on instruments providing long lasting satisfaction for productivity: robustness, repeatability, maintenance free capabilities, continuous measurement and resistance to high pressure and high temperature harsh environments. Manufacturers keep getting more sophisticated in their instrumentation technology as they develop new features and optimised characteristics to reach an optimum adaptation to industrial needs.

References

ASTM D2270-04 Standard Practice for Calculating Viscosity Index From Kinematic Viscosity at 40 and 100°C

ASTM D341 - 09 Standard Practice for Viscosity-Temperature Charts for Liquid Petroleum Products

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