Cambridge Viscosity

The Future of Oil Reservoir Analysis

How an industry known for resistance to change is driving innovation in viscosity measurement

By Jatinder Kalra

Understanding and characterizing fluid phase behavior is an essential part of reservoir engineering and simulation.

PVT (pressure, volume, temperature) labs conduct tests on thousands of samples each year to generate data on phase behavior, phase interactions, fluid compositions, GOR (gas-oil ratios), and key physical properties such as viscosity, density, and molecular weight. These tests are typically conducted at reservoir conditions of pressure and temperature that can range up to 30,000 psi pressure and temperatures up to (and on rare occasions, in excess of) 200ºC.

Traditionally, measurement equipment and instrumentation struggle in extreme conditions. It is rare to find an apparatus that operates at 30,000 psi and greater than 200ºC. This is usually due to limitations of the metals used in the manufacture of the instruments, which need to be both thermally stable and able to handle the corrosive fluids that could be produced from a well. As the pressure rating goes up, the temperature rating tends to come down to be able to stay within safe operating parameters of the metal in use.


Oil derrick and road in tundra, view from above

Viscosity, one of the key physical properties in characterizing fluid behavior, is measured using a viscometer. Currently in labs, the typical high-pressure viscometers in use are rolling ball viscometers, capillary viscometers, rheometers, vibrating wire viscometers, and oscillating-piston viscometers, which are also referred to as electromagnetic viscometers (EMV).

Cambridge Viscosity (now part of PAC) pioneered the EMV and introduced it to the market in the late 1980s. Their high-pressure viscometer (now ViscoLab PVT) started with the capability of handling pressure up to 10,000 psi. Later, that capability was expanded to 30,000 psi and 190ºC. Some models were also developed to accommodate ultra-high temperatures (300ºC). From its original market launch, the EMV slowly gained recognition and is now the leading viscometer used in most commercial PVT laboratories.

Changing Market Dyanamics of the Oil and Gas Industry

The oil and gas industry has seen some drastic shifts in the past decade. Enhanced oil recovery through fracking in shale and tar oil sands built up a glut of oil in reserve, sending the price of crude oil sharply down. As this was happening, environmental regulations made solar, biofuels, and other renewable energy sources more appealing, which was compounded by a push from environmental groups to reduce the carbon footprint. Courts ruled against the building of new pipelines to transport oil across the United States from Canada.

Canadian oil sand production facility from space. Image by Christian Pauschert.

Then, in 2020, the COVID pandemic shut down the world and demand plummeted. Today, the oil and gas industry appears to be recovering, with oil prices at their highest point in six years. This rebound, while welcome, continues to be fraught with uncertainty.

Oil and gas companies are on a mission to reinvent themselves. At a time when smaller companies and laboratories have folded, the larger players are proceeding with caution. Operating budgets are streamlined, and major producers and service companies have downsized significantly. Funding is being allocated to alternate energy generation, process automation, software modeling, intelligent technologies, and new innovations designed to reduce costs and capital requirements.

The measurement and analysis segment of the industry is also seeing change on the horizon. PVT labs are capital-intense projects. They are expensive to set up and expensive to run. To survive in an uncertain market, PVT labs are cutting costs everywhere possible. In some cases, this means reducing manpower. Reduction of manpower means doing the same with fewer people, which leads to automating processes to increase efficiencies, reducing cycle time to maximize productivity, developing software models using historical data to predict results instead of doing actual tests, and funding the development of new technologies that would cut the costs of making measurements.

One of those new technologies is known as lab-on-a-chip. It's an idea that has been around for many years, but it wasn't seriously considered while the oil and gas industry was making reasonable revenues from the traditional lab measurements. This is a technology that relies on the microfabrication of parts and being able to make traditional measurements on a small chip. There is now increased impetus in this direction and companies have emerged, touting the capability to measure various parameters using microfluidics. This includes measurements such as density and viscosity, and even some traditional lab measurements such as SARA (saturates, aromatics, resins, and asphaltenes). Currently, these devices do not have the capability to handle pressure or high temperatures; however, development is ongoing towards this capability, and even at a nano-fabricated level.

Wireless communications protocols and remote monitoring of processes have already expanded into mainstream plants and laboratories using IIoT (Industrial Internet of Things), where instruments and sensors are interconnected on a network and run via applications while gathering and storing data using cloud technology. The COVID pandemic expedited this trend when employees needed to work from home.

Lab Viscosity Measurements Today

In a standard commercial PVT lab, there are only five types of viscometers that might be found in use. (These were mentioned above.) Each has its strengths and limitations, and laboratories choose a specific type of viscometer depending upon the application and the fluid being tested.

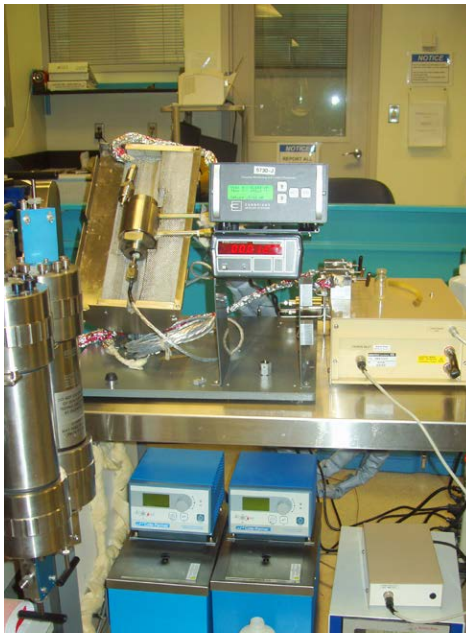
For very viscous fluids (viscosity above 20,000 cP, for example) that would not be heated to reduce the viscosity sufficiently, a capillary viscometer or a rheometer will be the instrument of choice.

The ViscoLab PVT was an innovative instrument that made it possible to capture measurements in just a few hours, when previously they took several days.

Vibrating wire technology was initially introduced in the 90s. However, the sensors were prone to damage, and it took some time before the sensors were packaged securely enough to operate under high pressure and temperature conditions. These sensors are now becoming more accepted for commercial use in fluid testing labs.

The electromagnetic viscometer (EMV) was introduced by Cambridge Viscosity in the 1980s, but they didn't branch into the oil and gas market with a high-pressure 340 version until the 1990s. The technology got the interest of DB Robinson and Associates (DBR), a fluid technology-based manufacturer and PVT lab located in Edmonton, Canada. This started a long association between the two companies. Cambridge leveraged the fluid and PVT expertise of DBR to enhance their sensors to accommodate pressures up to 20,000 psi and temperatures to 190ºC. They continued to invest in the product, making further improvements that included the ability to handle sour fluids.

The association continued even after the DBR group was purchased by Schlumberger in 2002. The viscometer eventually became known as the ViscoLab PVT, and DBR included it as a standard part of its PVT lab package that was sold to clients globally. Soon, the Cambridge EMV became a standard in many of the PVT labs around the globe, including all of the Schlumberger PVT labs.



A ViscoLab PVT viscometer set up in a DBR laboratory.

During 2014-2015, Research Partnership to Secure Energy for America (RPSEA) funded a study in the DBR lab to evaluate currently employed viscosity measurement techniques for both dead (non-pressurized) and live heavy oil samples (at reservoir pressure and temperature conditions), to compare the viscosity variations measured by different techniques and viscometers. Their goal was to recommend best practices and procedures for heavy oil viscosity measurements[1]. In this study, there were three different viscometers compared using the same fluids and under identical conditions. The three viscometers were a capillary viscometer (manufactured by DBR), a rheometer (manufactured by Anton-Paar), and the Cambridge ViscoLab PVT. It was concluded in this study that "the EMV and capillary viscometer provide reasonably consistent viscosity values for both dead and live heavy oil samples as long as key conditions related to the experimental setup, measurement procedures, and sample preparation are met. Both the EMV and CV are recommended viscometers for clean dead and live heavy oil viscosity measurements."[1]

The advantage that the EMV has over the other viscometers is measurement time. Calibration and setup of a capillary viscometer (CV) are fairly tedious and time consuming, and the measurement time is also quite long. Comparatively, the EMV can be calibrated and measurements obtained in a fraction of the time. The measurement range is wide enough to cover most of the commonly found oil samples from gases and very light fluids (<10cp) to fairly viscous fluids (up to 10,000 cP), and this is the reason the ViscoLab PVT has found acceptance in most labs as the standard instrument.

ViscoLab PVT+ — The Next Step

Based on the current and changing demands of the oil and gas industry, Cambridge Viscosity invested significantly in the next generation of its PVT viscometer. The ViscoLab PVT+ combines the user interface, pressure transducer, hub, and electronics in a single, compact enclosure. Its small footprint enables it to be easily transported to other areas or laboratories.

The ViscoLab PVT+ encompasses multiple product enhancements in one release. The ViscoLab PVT+:

ViscoLab PVT+ delivers accurate, fast, and reliable viscosity measurements in high-pressure environments.

- Consolidates all the measurement peripherals into one enclosure to save lab space
- Eliminates the laptop and the pressure display and adds a built-in control interface into the electronics
- Creates a single hub for communication between the pressure transducer, the viscometer sensor, and the bath
- Increases the span ratio of viscosity ranges from 20:1 to 50:1
- Offers analog inputs to access external device data, such as the pressure reading or a densitometer through the touchscreen
- Determines non-Newtonian behavior with sheer sweep test
- Runs pre-defined tests
- Calibrates quickly with slope/offset
- Improves graphing and reporting capabilities
- Features a built-in database for storing and recalling measurement results
- Expands the range within pistons, resulting in cost savings with a smaller piston set requirement, better repeatability, and higher precision with pistons
- Includes a USB port for data downloads in CSV format
- Uses new electronics that are common to all viscometer sensors, for a lower cost of ownership in terms of savings in spare parts
- Enables an easy upgrade of existing systems to move up to the new offering

With this first step towards the future of a connected lab, Cambridge Viscosity is directing the trajectory of its laboratory viscometer towards the future world of measurements.

References

[1] *. A. M. J. G. S. D. T. D. S. J. R. A. J. P. a. J. C. Hongying Zhao, "Heavy Oil Viscosity Measurements: Best Practices and Guidelines," Energy & Fuels Special Issue: 65th Canadian Chemical Engineering Conference. Energy Fuels 2016, 30, 5277−5290, May 2016.

About the Author

Jatinder Kalra has over 30 years of experience with fluid analysis equipment and fluid analysis laboratory operations. For many years, he managed manufacturing operations at DBR Design & Manufacturing, a company specializing in the manufacture of high-end fluid analysis lab equipment. After DBR was acquired by Schlumberger in 2002, Jatinder added the management of laboratory operations of the Schlumberger-DBR lab in Edmonton, Alberta to his list of responsibilities.

His expertise includes manufacturing planning, project management, manufacturing information systems, application of ISO 9000 quality systems, Inventory control and management, Supply chain management and operations management. Jatinder retired from Schlumberger after 34 years in the business, and now has a consulting company focused on helping small manufacturing businesses set up manufacturing operations, establish manufacturing and quality systems, address cash flow issues, hire qualified personnel, and grow and build their operations.

Jatinder Kalra
President, JKAL Consulting Services Inc
jkalra@shaw.ca