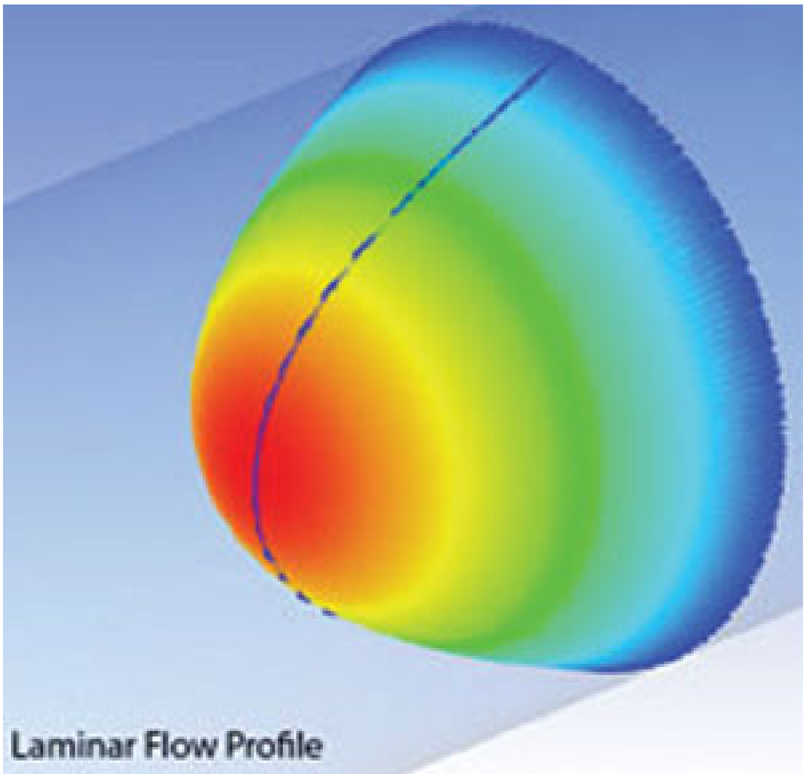
The Challenges Of Viscous Fluids

Measuring flow in fluids with viscosities of more than 100 centipoise (cP) requires special consideration by those responsible for operating and maintaining the equipment. In addition to heavy crude, other challenging high-viscosity products include: heavy fuel and lubricating oils, bunker fuels and grease components. In most cases, flow requires elevated temperatures, and flowmeters must be reliable in this environment.



During the last 10 to 15 years, ultrasonic meters have emerged as the primary choice for measurement as they offer improved accuracy and cost/benefit ratios for high-viscosity fluids. However, there are challenges associated with ultrasonic metering in such applications. In broad terms, these challenges are two-fold: being able to transmit a quality signal through the viscous fluid such that it can be detected by the receiving transducer, and being able to integrate multiple ultrasonic path measurements accurately and compensate for the variation in flow profiles that higher viscosity fluids can generate.

Signal Quality & Detection, & Transducer Selection

Transit-time liquid ultrasonic meters are inferential-type meters that derive the liquid flow rate by measuring the transit times of high-frequency sound pulses. Transit times are measured from sound pulses traveling diagonally across the pipe, downstream with the flow and upstream against the liquid flow. The difference in these transit times is related to the average liquid flow velocity along multiple acoustic paths. For the meter to work properly in high-viscosity applications, the received signal should be of high quality in order for its transit time to be measured.

The first challenge in high-viscosity applications is that sound pulses are more readily absorbed by the fluid. This means that the quality of the signal deteriorates (attenuates), and it becomes increasingly difficult to evaluate the timing.

When selecting an ultrasonic meter for high-viscosity applications, choose a meter with a transducer that can overcome the absorption levels and attenuation caused by higher viscosity fluids. For example, Daniel Measurement and Control's high-viscosity ultrasonic transducers—together with superior digital signal processing of received signals—allow its Model 3804 liquid ultrasonic meter to operate in fluid viscosities in excess of 1,000 cP in many applications.

High Viscosity & its Impact on Flow Profile

The second challenge in high-viscosity applications relates to flow profile. As fluid flows inside a pipeline, it does not have the same velocity across the entire diameter. The flow is faster in the center of the pipe than it is at the pipe wall. The distribution of flow velocity is called the flow profile. The shape of the flow profile depends upon the following parameters:

- The viscosity of the fluid.
- The density of the fluid.
- The mean flow velocity.
- The pipe's inner diameter.
- The upstream pipeline configuration.
- The interior pipe wall roughness.

Furthermore, for fully developed flow, there are two types of flow profile—laminar and turbulent.

Typically, laminar profiles have relatively high viscous fluid flows inside pipes with small pipe diameters at low mean velocities, whereas turbulent profiles have relatively low viscous fluid flows inside pipes with large pipe diameters at high mean velocities.

Flow regimes can be defined by using a non-dimensional parameter called the Reynolds number, which is calculated using:

$Re = pUD/\mu$ Where Re = Reynolds Number P = Density U = Fluid Velocity D = Pipe Diameter μ = Dynamic Viscosity

When the Reynolds number is less than or equal to 2,300, the flow is nominally laminar, whereas when the Reynolds number is greater than or equal to 5,000, the flow is nominally turbulent. The flow profile is considered in the transition region when the Reynolds number falls between 2,300 and 5,000.

Daniel Measurement and Control uses computational, analytical and empirical testing to fully characterize its Model 3804 liquid ultrasonic flowmeter over a wide range of Reynolds numbers, and consequently minimizes viscosity effects on the flow profile.

Advantages of Ultrasonic Meters

The advantages of using ultrasonic meters in high-viscosity applications are as follows:

- A high accuracy.
- A wide dynamic flow range.
- A negligible pressure drop.
- Non-intrusive operation and no moving parts, which makes it less susceptible to abrasive materials.
- Diagnostic functionalities.
- No need for an upstream strainer.
- Self-diagnostic capabilities.

Liquid ultrasonic meters provide best-in-class performance for a wide variety of high-viscosity applications. The two biggest obstacles—viscosity and flow profile—are now well understood and solutions to their challenges have been developed.

For more information, please visit Daniel Measurement and Control via www.daniel.com [1].