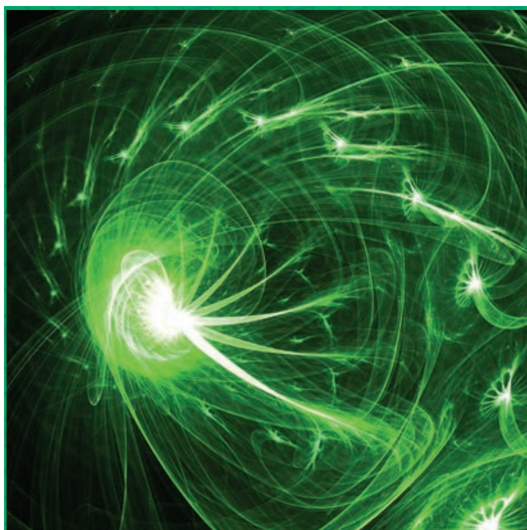

Metering Petrochemical Additive Injection Fluids

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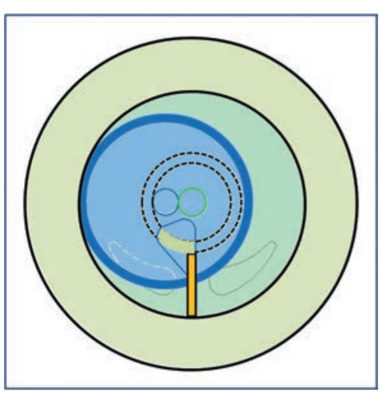
For the successful transportation and refining of crude oils a whole raft of additives are required. These vary from simple surfactants through to complex blended scale and corrosion inhibitors. These chemicals are injected in small quantities at high pressure and are critical to the whole refining process. Consequently, careful monitoring of their addition to any process is essential, and often this is best done using a flowmeter. Petrochemical additive injection fluids vary in both viscosity and density, and any flowmeter installed into a plant should be able to cope with a wide range of physical and chemical properties. The choice of flow measurement solutions is still quite narrow however, with only a few technologies offering acceptable measurement resolution.

Traditionally positive displacement meters have been the flowmeter of choice for petrochemical additive injection fluids. These meters are typically small with tight clearances between their moving components. Being small helps with the high pressure rating but because of the tight manufacturing tolerances they are susceptible to contamination, which can inhibit efficient operation or stopping the meter working all together - an inconvenience at the best of times, but very expensive if the meter is installed sub-sea. Non-invasive flowmeters meters with no moving parts are the most desirable but are also traditionally the most expensive.

This article reviews some of the currently used flowmeter technologies for this application and looks ahead to new advances on the development horizon.

Rotary piston meters

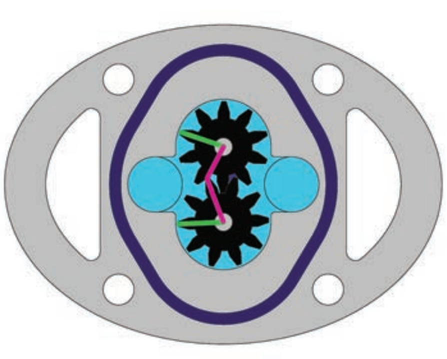


Rotary piston meters use a circular disc which "rotates" in a circular cavity. Each rotation displaces a known amount of fluid. Although the spindle circulates a central boss, the actual piston motion could be referred to as "nodding" as the circular element merely describes an oscillation bounded by the circular spindle track and the linear divider that causes the piston to slide in a "circular" motion within a round chamber. Fixed volumes of fluid are transferred both inside and outside the piston from the inlet to the outlet.

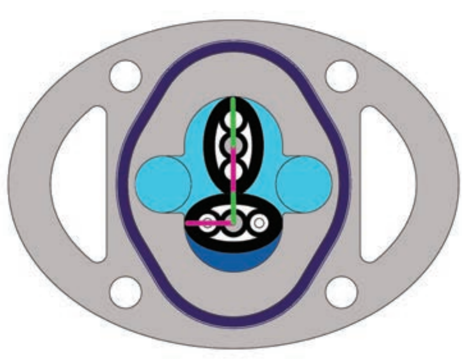
Manufacturers of rotary piston meters take great care in choosing materials which have low coefficients of friction as well as limited sliding areas. These techniques improve the flow meters linearity as well as extending the operating range. By definition these are typically low resolution meters. They normally have a single magnet in the central spindle but some devices will have multiple magnets in an oval pattern to increase the meters resolution. Unfortunately, metering of petrochemical additive injection fluids means that rotary piston meters have a lot of sliding surfaces and are extremely sensitive to contamination and wear.

Spur Gear & Oval Gear Meters

These two types of gear meter are superficially the same but operate in very different ways. A standard gear meter usually has a few very large gear teeth which are meshed in a chamber with close clearances on all surfaces. The teeth themselves form a seal along their length so the only possible leakage path is around the outside of the meshed cogs to the chamber walls. The pressure imbalance across the gears causes the gears to rotate displacing a volume of fluid approximately equal to one gear tooth volume. Usually a sensor is used to count the passing of each tooth generating a high resolution pulse train.



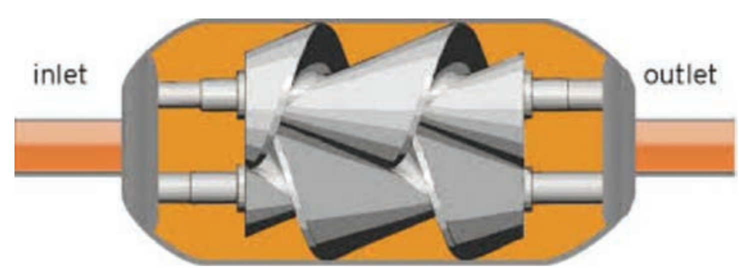
Spur gear meter



Oval gear meter

Oval gear meters rely on an entirely different theory. The teeth in an Oval gear meter are still used to drive the gear and seal the central path but the differential force is developed by the shape of the ovals not the gear teeth on the lobe. Oval Gear meters from different manufacturers include gears of varying oval shapes depending on the resolution and flow requirement of the target application. By using an oval shape a much greater driving pressure can be generated resulting in a wider flow range and lower pressure drop compared to a standard gear meter. This also permits the meters to operate satisfactorily with lower viscosity fluids. The displaced volume is a product of the oval shape not the gear profile shown in dark blue above. The sensor is usually magnetic with a detector at the face of the gear. The resolution is lower than the standard gear meter although multiple magnets can sometimes be incorporated.

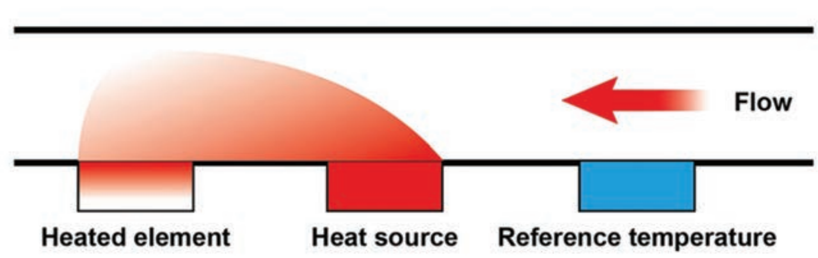
Helical Meters



Helical flow meters use a pair of helical gears rather like two Archimedes screws intermeshed. The chamber cross section is therefore similar to a figure of eight. The two rotors are "meshed" along their length and synchronised using a pair of ordinary gears at one end. As the fluid passes down the chamber it rotates the gears. They are very accurate devices and due the detection of motion taking place on the meshing gears, offer high resolution. They are, however, sensitive to contamination.

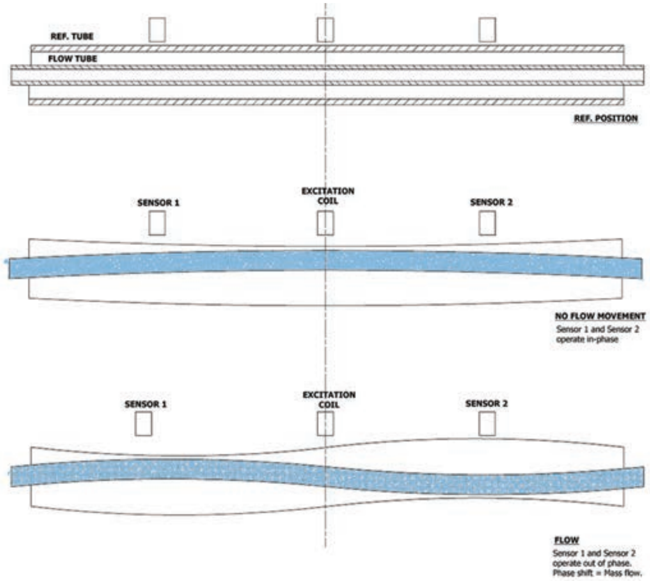
Thermal Meters

Accurate low flow thermal meters use two or even three elements. One element is used for reference temperature measurement. The second is a heat source, and the third measures the heat dissipation and so the flow rate. These are mass flow devices and they are capable of measuring very low flows although the thermal characteristics of the liquid must be known for precise measurement. Like the other electronic flowmeters, Coriolis and ultrasonic, there are no moving parts and they therefore offer good long term reliability.



Coriolis Meters

Coriolis meters still use moving parts but only minutely and on the outside of the flow tube. They use the fact that if a tube full of moving fluid is vibrated it will cause a reaction to the fluids movement proportional to the mass of fluid flowing in the tube. The faster the flow the greater the reaction. Coriolis meters detect the reaction of mass flow so they are inherently mass flow meters and will meter both volume and density. It is rather like trying to rotate a gyroscope at 90° to the spin axis where the external force will induce a reaction at 90° to the applied force. Such meters are very sensitive and will meter very low flows even with some contaminants extremely accurately - however they typically are also relatively expensive.



Ultrasonic meters

Ultrasonic meters have yet to join the armoury of petrochemical low flow metering tools in any appreciable way, but very low-flow high-pressure products are currently under development which will handle the flow rate as well as the very high pressure. Ultrasonic flow meters offer a very promising prospect as their manufacturing costs should permit a much lower installed cost than the desirable Coriolis although without the mass flow and density outputs which are not always required. These will be the preferred time of flight devices as Doppler shift meters are unlikely to ever attain the required performance. The prospect of a simple, straight through construction with high pressure capability and no moving parts at a competitive price should soon see a meter of this principle being available for these low flow applications.

Conclusions

Each one of above flow metering technologies has its own strengths and weaknesses and a choice will largely depend on financial constraints and personal experience. The rotary piston meter has a lot of sliding surfaces and is extremely sensitive to contamination and wear. The standard gear meter has a relatively high pressure drop and requires a fully lubricating fluid. Oval gear meters have relatively low resolution although this may not be an issue where the consumption and control of a fluid over 24 hours is important. Helical meters are more expensive than the other gear meters, require lubricating fluids and are also bulky. Thermal meters can be accurate but are typically set-up just to the fluid being metered so are not very versatile. Coriolis meters would appear to be the panacea for additive injection but their price is often prohibitive permitting a compromise in flow meter choice. I believe future developments in ultrasonic metering will bridge the gap with acceptable performance at an acceptable price. Ultrasonic flow meters will, no doubt, be a welcome addition to the low flow metering armoury.

About the Author

Trevor Forster is Managing Director of Titan Enterpises Ltd (www.flowmeters.co.uk) - a UK based company specialising in off-the-shelf and custom designed flowmeter system. Trevor has been in fluid handling since the mid-sixties when he started working on rotating seals and flowmeter design for third party clients. He formed Titan Enterprises in 1981 to specialise in small bore flow metering. Titan use innovative design and production techniques to build a product range that encompasses both old and new technologies whilst delivering excellent performance.