Coriolis vs. Ultrasonic Flowmeters

Comparing and contrasting two popular solutions for flow measurement

By Jesse Yoder, Ph.D.

It is interesting to compare Coriolis and ultrasonic flowmeters, as a great deal of new product development is occurring with both of these meter types. In addition, Coriolis and ultrasonic represent the two fastest growing flowmeter categories—with the possible exception of multiphase flowmeters. Both Coriolis and ultrasonic flowmeters are widely used in the oil & gas markets, and both are used for custody-transfer applications. The following article examines how these two meter types are alike, as well as how they differ.

Principle of Operation

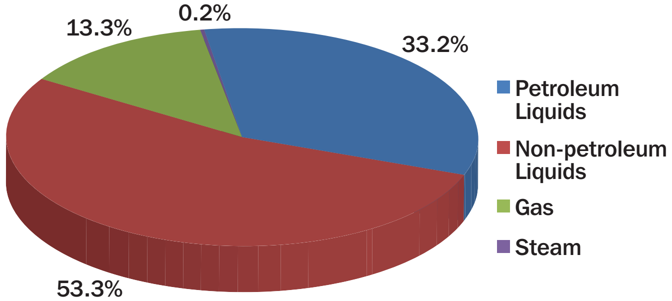
Despite their similarity, Coriolis and ultrasonic flowmeter have very different principles of operation. Coriolis flowmeters are composed of one or more vibrating tubes—usually bent. The fluid to be measured passes through the vibrating tubes. The fluid accelerates as it passes towards the point of maximum vibration and decelerates as it leaves this point. The result is a twisting motion in the tubes. The degree of twisting motion is directly proportional to the fluid's mass flow. Position detectors sense the positions of the tubes. While most Coriolis flowmeter tubes are bent, some manufacturers have also introduced straight-tube Coriolis flowmeters.

There are two main types of ultrasonic flowmeters—transit time and Doppler. Transit-time ultrasonic flowmeters have both a sender and a receiver. They send an ultrasonic signal across a pipe at an angle, and measure the time it takes for the signal to travel from one side of the pipe to the other. When the ultrasonic signal travels with the flow, it travels faster than when it travels against the flow. The ultrasonic flowmeter determines how long it takes for the signal to cross the pipe in one direction, and then determines how long it takes the signal to cross the pipe in the reverse direction. The difference between these times is proportional to flowrate. Transit-time ultrasonic flowmeters are mainly used for clean fluids, while Doppler meters are used for dirty fluids.

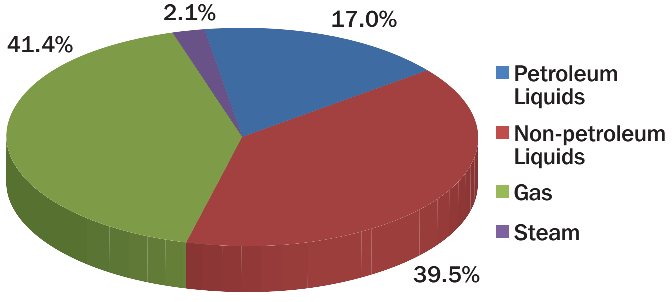
Early Adoption Issues

Ultrasonic flowmeters were introduced by Tokyo Keiki in Japan in 1963, while Coriolis flowmeters were first brought to the commercial market in 1977. After their introduction, both meters went through a difficult acceptance period. Many of the first ultrasonic flowmeters were clamp-on meters, and end-users had difficulty positioning them correctly. They also were not as accurate as later inline ultrasonic meters. In the 1980s, Panametrics (now part of GE Measurement & Control, *www.ge-mcs.com*) and Ultraflux (*www.ultraflux.net*) did research on using ultrasonic flowmeters for measuring gas flow. By the 1990s, ultrasonic meters had advanced technologically to the point where they began receiving wider end-

Shipments of Coriolis Flowmeters Worldwide by Fluid Type in 2011



Shipments of Ultrasonic Flowmeters Worldwide by Fluid Type in 2011



Source: Flow Research, Inc.

user acceptance.

Early Coriolis flowmeters had technical problems that interfered with their acceptance. Problems with vibration made it difficult to maintain zero point stability. End-users found the large size and weight of even two-inch or four-inch meters to be prohibitive. Their high price also presented an issue for many end-users, as Coriolis flowmeters are the most expensive meter, even today. By the 1990s, some of the technical issues with Coriolis flowmeters had been resolved. In 1994, KROHNE (*us.krohne.com*) introduced the first commercially successful straight-tube Coriolis flowmeter. This design addressed some problems with fluid build-up and pressure drop in bent-tube meters.

Differences In Line Size

Coriolis and ultrasonic flowmeters are dramatically different in terms of line sizes. Over two-thirds of Coriolis meters are made for line sizes of 2" or less. Until recently, the only Coriolis flowmeter above 6" was made by Rheonik (now part of GE Measurement). In the past five years, three more companies have introduced Coriolis meters for line sizes above 6". The companies include Micro Motion (a division of Emerson Process Management, *www.micromotion.com*), Endress+Hauser (*us.endress.com*), and KROHNE. These meters are designed for line sizes of 8" to 16", and they are mainly designed for custody transfer of oil and gas. While their price tag can be as high as $75,000, higher oil prices, and the increased value of natural and industrial gas, have made it beneficial for some companies to pay for the higher accuracy afforded by these large Coriolis meters.

While Coriolis meters excel in the lower line sizes, ultrasonic meters do best in line sizes of 4" and up. The larger diameters make the differences in transit time of the ultrasonic signal easier to detect, although they can perform well in smaller line sizes. Ultrasonic meters do not have the large line size limit that Coriolis meters have, and it is common for them to be made in sizes from 12" to 42", or even larger. Insertion ultrasonic meters can be used in pipes of any size, though so far no one has made an insertion Coriolis meter. Likewise, clamp-on ultrasonic meters give ultrasonic technology more versatility in check metering and temporary measurements. There is no clamp-on Coriolis flowmeter.

Both Flowmeter Types Benefit from Industry Approvals

Custody transfer of natural gas is a fast-growing market, especially with the increased popularity of natural gas as an energy source. Natural gas changes hands, or ownership, at a number of points between the producer and the end-user. These transfers are called custody-transfer points, and they are tightly regulated by standards groups such as the American Gas Association (AGA, *www.aga.org*). Other geographic regions have their own regulatory bodies.

One important function of the AGA and the American Petroleum Institute (API, *www.api.org*) is to establish standards or criteria for sellers and buyers to follow when transferring ownership of natural gas and petroleum liquids from one party to another. In the past, these groups have published reports on the use of orifice-plate meters and turbine meters for use in the custody transfer of natural gas. The importance of these reports is illustrated by the example of ultrasonic flowmeters. In the mid-1990s, a European association of natural gas producers called Groupe Europeen de Recherche GaziSres (GERG) issued a report laying out criteria to govern the use of ultrasonic flowmeters in the custody transfer of natural gas. This resulted in a substantial boost in the sales of ultrasonic flowmeters for this purpose in Europe. In June 1998, the AGA issued AGA Report 9, which also gave criteria for using ultrasonic flowmeters in natural gas custody-transfer situations. This caused a substantial boost in the sales of these meters for that purpose, especially in the U.S. The market for using ultrasonic meters to measure natural gas for custody transfer is one of the fastest growing segments of the flowmeter market.

The AGA approved a report on the use of Coriolis flowmeters for custody transfer of natural gas in 2003. This report is called AGA-11, and it is, in part, responsible for the overall positive growth rate of Coriolis flowmeters, which are now widely used for natural gas custody-transfer applications. Even though it often takes some time for end-users to adopt a new technology, this report has provided a significant boost to the use of Coriolis flowmeters for natural gas flow measurement.

The API has issued a draft standard entitled Measurement of Single-Phase, Intermediate, and Finished Hydrocarbon Fluids by Coriolis Meters. This document was added to the API Library in July 2012. A second draft standard called Measurement of Crude Oil by Coriolis Meters has also been approved by the API.

Ultrasonic Meters Do Well On Both Liquid and Gas

Both ultrasonic and Coriolis flowmeters do well on liquids. Ultrasonic meters are widely used on both hydrocarbon liquids and on water, and they perform well on both. Multipath ultrasonic flowmeters, meaning those with three or more paths, are used to measure the custody transfer of hydrocarbon liquids. Coriolis flowmeters are widely used to measure hydrocarbon liquids, especially for distribution purposes downstream from a refinery. Many of these are custody-transfer applications. Coriolis flowmeters are less widely used in the water and wastewater industry because the type of accuracy they afford is often not required in water and wastewater applications at this time. This may change in the future.

Ultrasonic meters excel in measuring the flow of natural gas. They are widely used for custody transfer of natural gas on pipeline transmission lines, where the pipe sizes can get quite large. The AGA-9 Report approves them for custody transfer of natural gas. Multipath meters are required for custody transfer of natural gas. The price tag on many of these multipath meters is in the range of $35,000 to $40,000.

Coriolis meters can measure gas flow, but it is not an ideal application for them. Gas is not as dense as liquids, and Coriolis meters rely on the momentum of the fluid to create the deflection necessary to measure flow. Even though gas is not the ideal medium for Coriolis meters, they have still had significant success in measuring gas flow.

Neither Meter Does Well with Steam Flow

While suppliers of Coriolis meters have tried to develop meters to measure steam, they have not been very successful so far. Like gas, steam is not as dense as water, and it is difficult to generate the necessary fluid momentum to deflect the meter sufficiently for a reliable flow measurement. In addition, the temperatures and pressures of some steam may exceed the tolerance measurement. The temperatures and pressures of some steam applications also exceed the limits of some Coriolis flowmeters, but steam measurement may be an area of future development for Coriolis flowmeter suppliers.

Ultrasonic flowmeter suppliers have had more success in measuring steam. For example, GE Measurement & Control has developed several ultrasonic meters that can measure steam flow. However, ultrasonic meters still account for a very small portion of those meters used to measure steam, as differential-pressure (DP) and vortex flowmeters remain the dominant technologies used to measure steam flow.

Where Do We Go From Here?

It is curious that two types of flowmeters could be so much alike and yet so different. For Coriolis flowmeters, the frontiers of development are larger line sizes, developing lighter and smaller meters, creating more accurate Coriolis meters for gas flow, and developing steam flowmeters. For ultrasonic meters, frontiers of development include getting more accuracy and performance out of multipath flowmeters, developing more accurate clamp-on flowmeters, having more calibration labs built, and improving steam flow measurement. FC


Jesse Yoder

Jesse Yoder, Ph.D., *is president of Flow Research Inc. in Wakefield, Mass., He has 25 years of experience as an analyst in process control. Dr. Yoder can be reached at jesse@flowresearch.com. For more on Flow Research's work in the area of Coriolis and ultrasonic flow measurement, visit www.flowcoriolis.com and www.flowultrasonic.com.*

www.flowresearch.com

FLOWSTREAM *Find related content @ flowcontrolnetwork.com…Search on:*

Flow Measurement | Coriolis Flowmeter | Custody Transfer | Jesse Yoder | Ultrasonic Flowmeter