Oscillatory PART I
FLOW MEASUREMENT

The first in a three-part series on oscillatory flow measurement. Part II takes an in-depth technical review of vortex shedding theory and operation. Part III takes a look at the unique swirlmeter and also analyzes fluidic flowmeters.

Multivariable: The Hot New Trend in Vortex Flowmeters

By Dr. Jesse Yoder

It is too soon to tell if vortex meters' growth rate will hit double digits, however, the new multivariable vortex meters, combined with the new reliability provided by digital signal processing techniques, offer the best chance yet that this can occur.

While vortex flowmeters were first introduced into industrial markets in the early 1970s, their history goes back farther than that. Vortex flowmeters make use of a physical principle involving the formation of vortex swirls (vortices) downstream of an obstruction placed in a flowing stream. Leonardo da Vinci in one of his notebooks first described this phenomenon around 1500. In 1911, Theodore von Karman did an analysis of the double row of alternating vortices that form when a flat object is placed in the path of flow. This phenomenon is now called von Karman's vortex street.

Vortex flowmeters make use of the effect studied by von Karman. They have a bluff body as a component, inserted in the flow stream. A bluff body is an obstruction with a broad, flat front. In a vortex meter, the bluff body is mounted at right angles to the flow stream. As the fluid impacts the bluff body, a series of alternating vortices is generated. Flow velocity is proportional to the frequency of the vortices. The vortex flowmeter determines vortex frequency by using one of several types of sensors, including pressure, thermal and ultrasonic. Flow rate is calculated by multiplying the area of the pipe times the velocity of the flow.

In some cases, straightening vanes of a specified length of straight upstream pipe is required to reduce swirl and distorted flow patterns. The accuracy of vortex flowmeters is medium to high, depending on manufacturer and model. Vortex flowmeters can be used to measure liquid, gas and steam flow. They are especially suited to measure steam flow.

Figure 1 Advantages and Disadvantages of New Technology Flowmeters

Type of Flowmeter	Advantages	Disadvantages
Coriolis	Very high accuracy; Provides direct mass flow measurement.	High initial cost; Limited application in pipe sizes above two inches due to size and cost.
Magnetic	High accuracy; Little pressure drop.	Cannot meter non-conductive fluids (e.g., hydrocarbons); Somewhat high initial cost, depending on size.
Multivariable DP	Provides mass flow measurement at economical cost; Provides additional data on process like temperature and pressure.	Requires use of primary element (e.g., orifice plate); Mass flow measurement is inferred rather than direct.
Ultrasonic Transit-Time	High accuracy; Non-intrusive.	May have high initial cost; Limited application to impure fluids.
Ultrasonic Doppler	Operates in dirty liquids; Non-intrusive.	Low-medium accuracy; Fewer suppliers than transit-time.
Vortex	No moving parts; Medium-high accuracy; Economical cost.	Vibration can affect accuracy; Lacks industry approvals.

Paradigm Case Applications

Paradigm case applications are those that a meter is ideally suited for. For vortex meters, paradigm case applications are clean, low viscosity, swirl-free fluids flowing at medium to high speeds. The presence of swirls is not ideal because swirls can interfere with the accuracy of the reading. The medium to high flow rates are required because vortices are generated irregularly at low flow rates. Erosion, corrosion or deposits that affect the shape of the bluff body can shift the calibration of the flowmeter, so vortex meters work best with clean fluids. Low viscosity fluids are preferred for vortex meters.

Comparison to Other Flowmeters

Vortex flowmeters are in the class of new technology flowmeters, which also includes Coriolis, magnetic, ultrasonic and multivariable differential pressure (DP) flowmeters. They do have some disadvantages compared to these other meters. For example, vortex meters are not as accurate as Coriolis meters, and they are more

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intrusive than ultrasonic meters. They are also more intrusive than magnetic flowmeters, and they do not have nearly as large an installed base as do magnetic flowmeters. Vortex flowmeters are more expensive than DP flowmeters. Yet despite these negative comparisons, vortex meters do have some significant advantages compared to other new technology meters. (See Figure 1, page 16.)

Vortex flowmeters offer accurate and reliable flow measurement, and at an economical cost. While vortex meters are not as accurate as Coriolis meters, many have accuracy readings of better than one percent, depending on the application and fluid. While vortex meters are more intrusive than magnetic and ultrasonic meters, they are far less intrusive than the orifice plates used with DP transmitters in flow measurement. Vortex meters introduce very little pressure drop, since most shedder bars are relatively small. One reason that vortex meters are less widely used than magnetic flowmeters is because they were introduced about 20 years later than magnetic flowmeters.

Yokogawa's digital YEWFLO vortex meter applies spectral analysis to the output of the shedder bar to reduce the noise in the signal.

Vortex flowmeters are one of the most versatile flowmeters. They can handle a wider range of process conditions than almost any other flowmeters. Vortex meters can readily handle liquids, gases and steams. While Coriolis meters are best known for being able to handle liquids, their use on gases is quite recent. Ultrasonic meters have been used for many years to measure liquid flow, and have been used since the 1980s to measure gas flow. However, the use of Coriolis and ultrasonic meters to measure steam flow is still in its very early stages, and magnetic flowmeters cannot be used for steam. By contrast, the use of vortex meters to measure steam flow is well established. Vortex meters can tolerate the high temperatures and pressures associated with measuring steam flow.

Factors Limiting Growth

In terms of growth rates, revenues from vortex flowmeters have been growing for the past few years at an average annual rate in the five percent range. In 2000, worldwide sales totaled $134 million. (See Figure 2, page 20.) This is slightly faster than magnetic flowmeters, but it is significantly slower than the 10 to 15 percent annual growth rates being recorded by Coriolis and ultrasonic flowmeters. This is due to a combination of factors.

One reason vortex meters have shown limited growth is that they do

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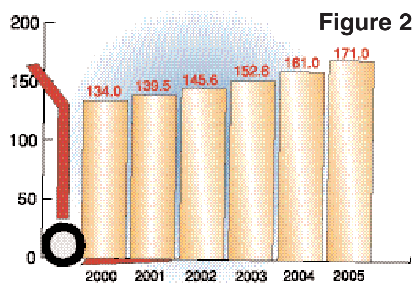

Total Shipments of Vortex Flowmeters Worldwide (Millions of Dollars)

not appear to have a single, compelling feature that makes users want them, or want them strongly. For example, users want Coriolis meters because of their high accuracy, and they want magnetic and ultrasonic flowmeters because they are largely non-intrusive. Vortex meters do not have a parallel outstanding feature. Instead, their popularity is due to a number of factors that, when taken together, make them a desirable meter.

Vortex flowmeters have a smaller installed base than any other new technology flowmeter, with the exception of multivariable DP meters. Vortex flowmeter revenues on a worldwide basis are substantially less than Coriolis, magnetic or ultrasonic meters. This means that there are fewer success stories for vortex meters than for other meter types. It is likely that vortex meters have substantial growth ahead.

Growth Factors for Vortex Meters

Even though vortex flowmeters have some factors limiting growth, they also have some very positive growth factors. One such factor is that vortex flowmeters are widely used for steam applications. Steam is the most difficult fluid to measure. This is due to the high temperature and pressure of steam, and because measurement parameters vary with the type of steam. Main steam types include wet, saturated and superheated steam.

Steam is often measured in power generation and in process plants. The primary flowmeters used to measure steam are DP and vortex. Vortex meters have no competition from magnetic flowmeters in steam flow measurement, and very little from ultrasonic or Coriolis. Besides being able to handle the high pressures and temperatures, vortex meters have wide rangeability. This enables them to measure steam flow at a variety of velocities.

District heating is another important growth area for vortex flowmeters. In district heating, a centralized heating system provides heat for a building, a group of houses or even a town. District cooling works in a similar way. A volumetric flowmeter is often combined with a temperature sensor and pressure transmitter in district heating to measure mass flow. A flow computer is used for the mass flow calculation. Both vortex and ultrasonic meters are used in district heating to measure water flow, as well as steam flow.

The availability of multivariable flowmeters is another important growth factor for vortex flowmeters. Sierra Instruments introduced the first multivariable vortex flowmeter in 1997. Multivariable flowmeters combine a temperature sensor and a pressure transducer with a vortex flowmeter. The flowmeter can determine volumetric flow, temperature, pressure, fluid density and mass flow by using the information from these sensors. Instead of using a separate flow computer to perform the mass flow calculation, multivariable flowmeters have this computational capability built in.

Multivariable flowmeters are one of the fastest-growing segments of the flowmeter market. End users like them because they provide more information about the process than a single variable volumetric meter. They also typically provide this information at less cost than buying comparable components separately. The cost of a multivariable flowmeter is usually less than the cost of a volumetric meter, plus a temperature sensor, a pressure transducer and a flow computer. Multivariable meters provide a cost-effective way to measure mass flow without going to the higher cost of a Coriolis meter. Besides multivariable vortex meters, there are multivariable DP, magnetic and ultrasonic flowmeters.

New Trends

Vibration has traditionally been a problem for vortex flowmeters. Suppliers have dealt with this problem by using advanced software techniques to reduce noise in the signal. Yokogawa's digital YEWFLO vortex meter uses digital signal processing (DSP) techniques to create a more reliable flow signal. By applying spectral analysis to the output of the shedder bar, the new meter reduces the noise in the signal. The digital YEWFLO also offers enhanced diagnostics.

Other suppliers are addressing the issue of noise and vibration. Emerson has had a feature called Adaptive Digital Signal Processing in its vortex flowmeters for a number of years. ABB has introduced the Trio-Wirl, a vortex meter that uses digital signal processing to deal with noise and vibration. ABB began shipping the Trio-Wirl towards the end of 2001. Other major players in the vortex market, besides

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Yokogawa and Emerson, include Endress + Hauser and Foxboro. Oval competes with Yokogawa in the Japanese and Asian markets.

The pace of the trend towards multivariable vortex flowmeters has suddenly picked up. J-TEC Associates introduced a new multivariable vortex meter at the ISA show in September 2001. The JI and JW series meters have an RTD temperature sensor mounted in the bluff body. A pressure transducer can also be included to provide a pressure reading. An onboard microprocessor can be used to calculate the mass flow rate. The JI and JW meters can be used on liquid, gas and steam.

Yokogawa Japan also introduced a multivariable version of its digital YEWFLO in the first part of 2002. This new product has an RTD embedded in the bluff body to provide a reading of process temperature. The new multivariable YEWFLO will be introduced in the United States later this year. A more robust version that includes pressure measurement will be released at a later time. Foxboro expects to introduce a multivariable vortex flowmeter by the end of 2002 or early in 2003.

A Look Ahead

The improved flow signal offered by the new products that incorporate DSP technology will certainly make vortex flowmeters more attractive to some users. The success of these new products depends in part on the extent to which manufacturers can educate end users about the value of the new technology. Success stories from users who try the products will help to spread the word.

Look for more suppliers to get into the multivariable vortex flowmeter market. While four years passed between the introduction of Sierra's multivariable vortex meter and J-TEC's multivariable vortex, multivariable has become the hottest trend in the vortex flowmeter market today. It is interesting to see companies offering different degrees of multivariable capability.

Will vortex flowmeters ever have the same type of sales as other new technology meters? Coriolis meters have very high accuracy, ultrasonic meters are riding the wave of their use for custody transfer of natural gas and magnetic flowmeters are the meter of choice in Europe. It is too soon to tell if vortex meters will catch a wave that will propel their growth rate into double digits. The new multivariable vortex meters, combined with the new reliability provided by digital signal processing techniques, gives them their best shot at this lofty goal. FC

About the Author

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