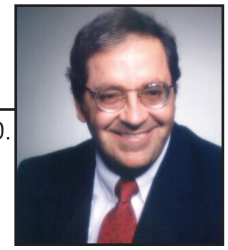
by Jesse Yoder, Ph.D.



7 Technologies for Steam Flow

Pros & Cons of Leading Measurement Methods

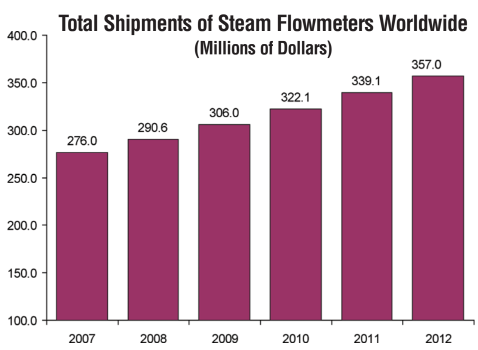
The past few years have brought a great deal of attention to energy production and use. The rising price of crude oil has affected many areas of our economy, including by such impacts as higher gasoline prices, rising jet fuel prices, and increased heating oil costs.

Steam flow measurement is important in this context because steam is widely used as a source of power in the production of electricity. In today's power plants, heat is obtained from multiple sources. These include fossil fuels, such as coal, natural gas, or oil, as well as other sources of heat, including nuclear fuel, waste fuels, solar energy, and geothermal energy. The heat energy in these sources of heat is released, either through combustion or through a similar process. The heat is transferred to water, which generates steam. In many cases, this steam is then used to drive an electric generator. The system used to generate the steam is called a boiler.

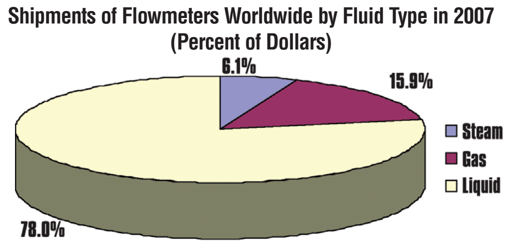
As the costs of energy rise, many companies are looking to increase efficiencies in their energy and power generation. As a result, more attention is being paid to steam flow measurement.

Steam flow measurement accounts for about 6 percent of the revenues from flowmeters sold in today's $4.5 billion flowmeter market. While as many as seven different types of flowmeters can be used to measure steam flow, the vast majority of steam flow measurements are made with differential-pressure (DP) and vortex flowmeters.

1. Differential-Pressure



CAGR = 5.3%



2007 = $4.5 billion

Flowmeters

DP flow transmitters together with primary elements account for well over half of the flowmeters sold for steam flow applications. DP flow transmitters sold for steam flow have many of the same advantages and disadvantages of DP flow transmitters sold to measure liquid and gas flow. Disadvantages include pressure drop, interference with the flowstream, and wear over time. DP flow transmitters also have limited rangeability and are reliant on the square-root method for calculating flow.

On the one hand, DP flow transmitters offer some pretty compelling advantages when it comes to steam flow measurement. For example, they are relatively inexpensive and offer straightforward installation. DP flow is also the most studied and best understood method of flow measurement, and multivariable DP flow transmitters are capable of measuring more than one process variable, such as differential pressure, process pressure, and temperature, which in turn enables the measurement of mass flow.

The effectiveness of a DP flow transmitter for steam flow depends on the primary element used. Flow nozzles are well suited for steam flow because they can handle the high temperatures and pressures that accompany steam flows. Orifice plates are widely used to measure steam flow. In fact, all the primary elements, including Pitot tubes, Venturi tubes, and wedge elements can be used for steam flow measurement.

2. Vortex Flowmeters

Vortex flowmeters have some advantages over other types of new-technology flowmeters when it comes to measuring gas and steam flow. Gas flow measurement is still a relatively new application for Coriolis meters, and the use of Coriolis meters to measure steam flow is just beginning to occur. While ultrasonic meters have been used for a number of years to measure gas flow, steam flow is a very new application for them. Magnetic flowmeters cannot be used to measure either gas flow or steam flow. Multivariable differential-pressure flowmeters can be used to measure liquid, gas, and steam. However, most multivariable DP flowmeters have substantially greater pressure drop than vortex meters, due to the presence of a primary element.

Steam is the most difficult fluid to measure. This is due to the high pressure and high temperature of steam and because the measurement parameters vary with the type of steam. Main types of steam include wet steam, saturated steam, and superheated steam. Steam is often measured in process plants and for power generation. In addition to their ability to tolerate high process temperatures and pressures, vortex meters offer wide rangeability, which enables the measurement of steam flow at varying velocities. In process and power plants, steam is often measured coming from a boiler.

3. Variable-Area Flowmeters

Variable-area meters, also called rotameters, have a limited use for steam applications. One reason is that many of them do not have an output signal and must be manually read, although some companies have developed variable-area meters with an output signal. Most process and power plants today are highly automated and would find a flowmeter that has to be read manually of limited value.

Another reason for the limited use of variable-area flowmeters is that they have low accuracy. Many variable-area meters have accuracy levels in the +/-5 to +/-10 percent range, which is generally not suitable for measurements in process and

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power plants. If end-users want to go to a low-cost meter, they will be more likely to try a DP flowmeter than a variable-area meter.

Variable-area meters do have the advantage of being low cost though, so they are a good fit for noncritical measurements where high accuracy is not a requirement.

4. Target Flowmeters

While target flowmeters can be used for liquid, gas, and steam applications, they are predominantly used to measure steam flow. Target meters can measure both superheated and saturated steam. While the target is subject to wear, this can be compensated for with recalibration. The target meter has no moving parts, and it can withstand pressures up to 15,000 PSIG and temperatures up to 500 F. Target meters can fit into almost any line size above 3/8".

Even though target meters were developed after 1950, they are classified as a traditional-technology flowmeter, due to their primarily mechanical means of construction. It is not obvious why more suppliers have not chosen to offer this meter, because, in many ways, the target meter is most like a vortex meter. Target meters rely on a body inserted into the flowstream, not unlike the bluff body that characterizes vortex meters. However, instead of counting vortices generated by the bluff body, like a vortex meter, a target meter measures the force exerted on the target by the fluid.

5. Turbine Flowmeters

Turbine flowmeters are widely used for liquid and gas applications, but they have very limited use for steam flow measurement. One major issue has to do with the effect of condensation on measurement accuracy. When condensation occurs in a flowing stream, the fluid becomes a mixture of steam and water, which creates two-phase flow. The condensate can harm the blades, and interfere with measurement accuracy.

Turbine flowmeters do have an advantage since they can perform better at low flowrates than vortex flowmeters. They also have a good turndown ratio (some suppliers claim a turndown of 25-to-1). The most favorable condition for steam flow measurement by turbine meters is measurement of dry steam. However, because steam is so readily influenced by changes in temperature and pressure, steam flow conditions can change very quickly. Steam is most stable at the boiler, but cold spots can occur in the line, bringing about condensation.

6. Coriolis Flowmeters

Coriolis flowmeters can be classified as an emerging technology for steam flow measurement. Like turbine meters, Coriolis meters have difficulty handling condensation in steam. When steam condenses, the water droplets create two-phase flow, a mixture of steam and water. The presence of water interferes with the accuracy of the flow measurement.

Coriolis flowmeters can work to measure flow with dry steam. However, because steam is easily affected by variations in temperature and pressure, steam-flow conditions can change very quickly. There remain some technical challenges for Coriolis suppliers to resolve before Coriolis meters can be a major part of the solution for steam flow measurement.

7. Ultrasonic Flowmeters

Ultrasonic flowmeters have many advantages over both traditional and new-technology flowmeters. They are minimally invasive, have high accuracy, cause little-to-no pressure drop, and they have no moving parts. However, there are some technical limitations that make steam flow a difficult application for ultrasonic flowmeters.

One limitation of ultrasonic flowmeters applies to clamp-on flowmeters. The speed with which an ultrasonic wave travels through metal may be different than the speed of the wave through steam. This can interfere with the accurate calculation of the flowrate of the steam. In addition, the exact thickness of the pipe is not always known, either because there is buildup or deposits on the pipe wall or simply because this is an unknown variable. This pipe-thickness issue applies to all clamp-on flowmeters, whether they are measuring liquid, gas, or steam.

A limitation of spoolpiece ultrasonic flowmeters is that the transducers can become overheated due to the temperature of the steam. If this happens, it can ruin the transducers. While some ultrasonic flowmeter suppliers have found a way to successfully deal with this issue, it remains an important technical challenge.

Vortex Offers a Safety Net

Some suppliers of turbine, Coriolis, and ultrasonic technologies for steam flow measurement have added vortex meters to their product line so as to have an alternative technology to offer end-users who may have difficulty measuring steam with a given technology. The function that vortex meters have as a kind of back-up meter, or safety net, for companies offering difficult-to-apply technologies is likely to grow as end-users increase their willingness to try new technologies for measuring steam.

Vortex flowmeters are very reliable when used to measure steam flow, they cause minimal pressure drop, and they can handle high pressures and temperatures. The ability of vortex meters to measure steam flow will encourage suppliers of alternative technologies to further develop and promote their alternative technologies for steam flow measurement, knowing that they can always fall back on their vortex meters for difficult applications. FC

Jesse Yoder, Ph.D., is president of Flow Research, Inc. in Wakefield, Mass., a company he founded in 1998. He has 20 years of experience as an analyst and writer in process control. Dr. Yoder specializes in flowmeters and other field devices, including pressure and temperature products. He has written over 100 market research studies in industrial automation and process control, and has published more than 70 journal articles. Dr. Yoder can be reached at jesse@flowresearch.com or 781 245-3200.

www.flowresearch.com

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