Thermal & vortex flowmeters improve efficiency in energy management

The technology continues to grow with frequent advancements.

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Steam plays an important part in people's lives. It is important in food preparation, for cooling and heating buildings, in the pulp and paper industry, and as a source of power for ships. Probably its most important use is for electricity production.

Steam power plants get their energy from a variety of sources. These plants need a source of fuel to heat water and generate steam. Many use fossil fuels such as coal, oil or natural gas for energy, while others use nuclear energy. Renewable sources of energy for steam power plants include solid waste, wind, geothermal and biomass. All these energy sources produce heat, which heats water to generate steam.

In a power plant, the steam turns a turbine that is built somewhat like a windmill and rotates on a wheel made of tightly packed metal blades. The turbine is connected by an axle to a generator, which spins around with the turbine blades. As the generator turns, it uses the kinetic energy from the turbine to generate electricity.

Gas & air flow measurement

Many power plants use natural gas as the fuel that is burned to generate steam. This natural gas has to be precisely measured and efficiently managed to ensure the safe and reliable operation of the power plant's heat source. Managing and controlling the optimal fuel-to-air ratio requires a mass flow calculation — and can reap big dividends if it is done correctly. This type of precise and efficient management ensures lower overall fuel costs. Some facilities may require that gas distribution and billing be tracked.

Another important factor in this context is the measurement of compressed air. Natural gas must be precisely measured and managed, so the effective management of compressed air in a power plant can reap big dividends. Just as in apartment buildings where water flow is at its peak in the morning and evening, but minimal later at night, so power requirements in a power facility can vary widely with time of day. This gives thermal flowmeters an advantage in these types of applications because they typically have a 100-to-1 turndown and can measure low flows as effectively as high flows. They are also not subject to clogging, unlike turbine and Pitot tube meters.

How steam is measured

As part of the electricity production process, steam must be measured to maximize boiler efficiency. Differential pressure (DP) flowmeters dominate steam flow measurement. DP flowmeters rely on a constriction placed in the flow line that creates reduced pressure in the line after the constriction. A DP flowmeter requires a means to detect the difference in upstream versus downstream pressure in the flow line. While this can be done with a manometer, DP flowmeters use DP transmitters that sense the difference in pressure, and then use this value to compute flow rate.

Vortex flowmeter advantages

Despite the dominance of DP flowmeters, some end users are turning to multivariable vortex meters for measuring steam flow. 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 and boiler feedwater flow, steam flow is a new application for them.

Magnetic flowmeters cannot be used to measure gas flow, steam flow or nonconductive liquids such as

Figure 1. Flowmeter for steam measurement
All graphics courtesy of Flow Research

hydrocarbons. Multivariable DP flowmeters can be used to measure liquid, gas and steam. However, most multivariable DP flowmeters have substantially greater pressure drop than vortex meters because of the presence of a primary element.

One reason vortex flowmeters work well with steam is that they can handle the high temperatures and pressures associated with steam flow measurement. This is one limitation of ultrasonic flowmeters. The ultrasonic transducers of inline meters, which send and receive the ultrasonic signals, have to be able to tolerate the high temperature of steam. For vortex meters, only the bluff body and the sensors that detect the vortices are in contact with the flow. The transmitter is usually mounted somewhere away from the pipe.

Vortex flowmeters are well-suited for measuring steam flow, and they are widely used for this purpose. Steam is the most difficult fluid to measure. This is because of the high pressure and high temperature of steam and because the measurement parameters vary with the type of steam. The 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 have wide rangeability. This allows them to measure steam flow at varying velocities. In process and power plants, steam is often measured coming from a boiler.

Multivariable vortex flowmeters measure multiple variables in one instrument. In particular, they measure volumetric flow, pressure, temperature, mass flow and density. The density of saturated steam changes with temperature or pressure, while the density of superheated steam depends on temperature and pressure. Because multivariable flowmeters measure density accurately, they provide an accurate measurement of mass flow. With steam flow accuracy of 1 percent of reading and a wide 30-to-1 turndown, they provide the necessary data for reliable and efficient steam flow management.

An integrated approach using software & firmware

Many companies have made conscious efforts to reduce the number of suppliers on whom they rely for products and services. Qualifying approved suppliers can be costly and time-consuming. Having fewer suppliers makes it more likely that products purchased will be compatible. It also makes for fewer points of contact when service or maintenance is required.

In flow energy management, for example, Sierra Instruments became a single-source supplier by offering three types of flowmeters that measure gas, steam, air and water. Multivariable vortex meters measure as many as five process variables: volumetric flow, mass flow, density, pressure and temperature.

Figure 2. Close-up of thermal mass flowmeter, part of Sierra Instruments' Big-3 for flow energy applications

Companies build on flowmeter advancements

Sierra was the first company to introduce multivariable vortex flowmeters in 1997. Since then, other companies such as ABB, KROHNE Inc. and Yokogawa have brought them out. Multivariable vortex meters compete with multivariable DP meters and Coriolis meters. While all three measure gas flow, Coriolis meters have an accuracy advantage, although they typically are more accurate in measuring liquid flows than in measuring gas flows. Coriolis and vortex meters have 16-inch line size limitations. This limitation makes them unable to measure natural gas flow in large pipeline, which can range from 20 to 42 inches and above.

Other innovations in vortex flowmeters include reducer vortex and dual sensor vortex meters. Reducer vortex meters make it possible for these meters to measure lower flow rates. Dual sensor vortex meters add redundancy by incorporating two vortex meters together in the same line. These innovations introduced in the past 10 years have made vortex flowmeters more accurate, redundant and reliable. With increased industrialization worldwide, their use to measure steam in power plants and for other steam and gas applications can be expected to increase.

As is the case with multivariable vortex meters, multiple companies have introduced advances in thermal flowmeters. Sierra was one of the original companies to introduce thermal flowmeters in the mid-1970s, along with Kurz Instruments and Fluid Components International. In the early 1990s, the need for continuous emissions monitoring spawned the rise of multipoint thermal flowmeters. Since 2008, much thermal flowmeter development has centered greenhouse gas emission measurement.

Flow measurement requirements for steam and gas applications are increasing along with a continued need to monitor and measure carbon dioxide emissions. As a result, expect continued growth in the multivariable vortex and thermal flowmeter markets. Based on what the industry has already seen, suppliers will be there to meet these measurement challenges with innovative solutions. FC

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