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SELECTING NEW TECHNOLOGY: PROBLEM SOLVING

Using meters to measure steam flow

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Key Concepts

- Types of steam--wet, saturated, and superheated--influence selection of the flow measuring device.
- As measurement becomes more accurate, the meter's price increases.
- Installation varies for each type of flowmeter.

When people hear about fluid measurement, they usually think of checking either liquid or gas flow. This belief is natural, since about 90% of fluid measurements are for these two applications. In a worldwide survey of flowmeter users, 68% measured liquids, 22% gas, and only 10% steam.

While 10% may not seem like a large percentage, it represents a significant number of measurements. Many companies measure steam for purposes of internal custody transfer and for utility applications in power generation and chemical plants.

Steam types

While all steam may look the same, the way it is measured varies with the type: wet, saturated, or superheated.

Wet steam

Wet steam is probably the most difficult type to measure. It contains both condensed hot-water particles and steam, and is considered two-phase flow. Wet steam is difficult to measure with any of the technologies currently available, and accuracies can vary.

Saturated steam

Saturated steam occurs at a particular pressure and corresponding temperature when a state of equilibrium exists between liquid and vapor states; for example, at the end of the boiling process when only steam is present.

Superheated steam

Superheated steam is at a higher temperature than the saturation temperature at the same pressure. Thus, it occurs when saturated steam is subjected to an increase in temperature while the pressure remains constant or is decreased while the temperature remains the same.

In a boiler, steam is saturated. As steam leaves a boiler, a pressure drop is created by the flow. Reduced pressure, along with a relatively constant temperature, results in superheated steam, which acts as a gas and conforms to general gas laws.

Flowmeter types

Steam flow is measured with several types of flowmeters: differential pressure-based (orifice plates, flow nozzles, venturi tubes, and averaging pitot tubes), vortex, Coriolis, and ultrasonic. For specific applications contact the manufacturer for recommendations based on steam type, flow rate, and operating conditions.

Differential pressure-based flowmeters

Differential pressure-based flowmeters measure steam flow by using a primary element to cause a pressure drop. Flow rate varies with the square root of the pressure drop across the primary element. Pressure drop is measured with a differential pressure (DP) transmitter.

Orifice plates contain a hole or orifice through which liquid passes. Upstream and downstream piping are required to condition the flow and provide for accurate measurement. Pressure is measured upstream and downstream from the orifice plate with a DP transmitter, which then calculates the flow rate.

Flow nozzles (Fig. 1) have a narrow opening for steam to pass through. One of the most common uses of flow nozzles in the power industry is to measure the amount of steam going to a turbine.

Fig. 1. Flow nozzles for high-velocity and high-temperature

Pipe.jpg (12636 bytes)

jobs are usually manufactured from stainless steel to prevent corrosion of the polished throat.

They are used primarily for high-velocity and high-temperature applications, and work best with fluids whose Reynolds numbers are at or above 10,000.

Venturi tubes consist of a tapered inlet and outlet with a straight section in the middle that is narrower than the pipe diameter. They have a length of about eight pipe diameters. Pressure drop is lower than with orifice plates.

Upstream pipe requirements are less stringent than those for orifice plates or flow nozzles, and they do not require straightening vanes. On the other hand, venturi tubes are more difficult to manufacture with precision than orifice plates or flow nozzles, which makes them more expensive. Their size makes them difficult to inspect and change.

Averaging pitot tubes (Fig. 2) consist of an insertion sensor spanning the full pipe diameter that detects an impact and reference pressure through a series of ports on the upstream and downstream faces. By averaging pressure signals, a differential signal is created that resembles the signal produced by an orifice plate meter.

Fig. 2. Averaging pitot tubes span the entire pipe diameter, are easy to install, and provide an inexpensive way to measure steam. (Courtesy Rosemount, Inc.)

Valve.jpg (13844 bytes)

Vortex flowmeters

Vortex flowmeters (Fig. 3) are becoming widely used for steam flow measurement. They operate on a principle known as the von Karman effect. According to this principle, fluid that passes a bluff body generates vortices alternately on either side of the body. Frequency of vortices generated is proportional to the flow rate of the fluid.

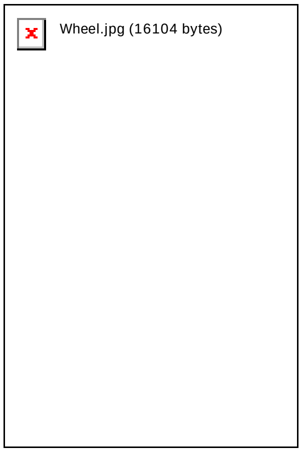

Fig. 3. Vortex flowmeters have a barlike or bluff construction that allows for the passage of dirt. (Courtesy Yokogawa Industrial Automation)

Although vortex flowmeters cost more than DP-based transmitters and orifice plates, their installed cost is comparable to that of orifice plate flowmeters because of the additional expense of the mounting systems and pressure taps required for orifice plate meters.

Vortex meters, like DP-based flowmeters, are also sensitive to inlet flow conditions, and may require straightening vanes or straight pipe runs to obtain required accuracy.

Coriolis flowmeters

Coriolis flowmeters directly measure mass flow rate. They have one or more bent, straight, or U-shaped vibrating tubes in the fluid stream. As the fluid passes through the tubes, they twist. The amount of tube twisting is directly proportional to mass flow. This meter can also be used for heat measurement of low-pressure, superheated steam.

The chief advantage of Coriolis flowmeters is providing highly accurate measurements of mass flow rate without flow conditioning or accessory devices such as pressure or temperature measurement.

Ultrasonic flowmeters

Ultrasonic flowmeters measure the time it takes an ultrasonic pulse to travel back and forth across a pipe at an angle. When the pulse travels with the flow, it moves quicker than when it travels against the flow. Difference between these times is proportional to the flow rate. These meters are especially suited for measuring flow in large pipes. As with Coriolis meters, they have a relatively high initial cost.

While DP-based flowmeters are thoroughly entrenched as a means to measure steam flow, the newer technologies of vortex, Coriolis, and ultrasonic measurement are used more often. One disadvantage the newer technologies have is that fewer standards have been written for them, which limits their use.

Related info

- Comparing flowmeters

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More info

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[Top]

Comparing flowmeters

Type	Advantages	Disadvantages
Orifice plate	Low cost Inexpensive installation No moving parts	High pressure loss Low rangeability Flow conditioning
Flow nozzle	Moderate price	Difficult installation Difficult cleaning
Venturi tube	Low pressure drop Simple upstream requirements	High cost Limited rangeability Awkward size

Averaging pitot tube	Accuracy does not degrade with use Low pressure drop	Not suited for low flow rates High cost
Vortex	Easy to install Low maintenance Moderate installed cost Good accuracy	Sensitivity to vibration and inlet flow
Coriolis	High accuracy No flow conditioning	High initial cost
Ultrasonic	Non-intrusive No pressure drop Works in large pipe diameters	High initial cost

[Top]

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