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Flowmeter Selection

When a flowmeter is needed, the selection process should include studying the characteristics of respective measurement technologies and analyzing the advantages/disadvantages for different plant environments. This effort will help ensure that a meter with the right performance and reliability, for a particular installation, is selected. Some of the most common industrial flowmeter designs are described here.

Flowmeter	Accuracy (full scale, F; rate, R)	Turn-down	Fluids (liquid, gas, solid, slurry)	Pipe Sizes, in.	Maximum pressure, psig	Tem-perature range, (° F)
Square-edged, orifice differential pressure	0.5–1.5% R	4 to 1	L, G, S	0.5–40	8,800	–4–2,300
Electromagnetic	0.2–2% R	10 to 1	L	0.15–60	5,000	–40–350
Turbine	0.15–1% R	10 to 1	L, G	0.5–30	6,000	–450–600
Ultrasonic (doppler)	1–30% R	50 to 1	L, G, SL	0.5–200	6,000	–40–250
Ultrasonic (transit time)	0.5–5% R	down to zero flow	L, G	1–540	6,000	–40–650
Vortex	0.5–2% R	20 to 1	L, G, S	0.5–16	1,500	–330–800
Positive displacement	0.152% R	10 to 1	L	0.25–16	2,000	–40–600
Coriolis	0.1–0.3% R	10 to 1, to 80 to 1	L, G	0.06–12	5,700	–400–800
Thermal (gases)	1% F	50 to 1	G	0.125–8	4,500	32–572
Thermal (liquids)	0.5% F	50 to 1	L	0.06–0.25	4,500	40–165

DIFFERENTIAL PRESSURE

A differential pressure meter operates by measuring the pressure differential across the meter and extracting the square root. These meters have a primary element that causes a change in kinetic energy, which in turn creates differential pressure in the pipe. A secondary element measures the differential pressure and provides a signal or readout, which is converted to the actual flow value.

Two basic types of primary elements rely on this measurement: orifice plates and Venturi tubes. Both element types rely on the law of conservation of energy and Bernoulli's energy equation to determine volumetric flowrates.

ELECTROMAGNETIC

Electromagnetic meters (commonly referred to as "mag" meters), employ Faraday's law of electromagnetic induction, which states that voltage will be induced when a conductor moves through a magnetic field. The liquid serves as the conductor. Energized coils outside the flow tube create the magnetic field. The amount of voltage produced is directly proportional to the flowrate.

Magnetic flowmeters are only applicable for fluids with some electrical conductivity, typically those with conductivity values above 5 μS/cm. Most aqueous solutions contain enough conductive dissolved solids to meet this requirement. However, ultrapure water, some solvents, and most hydrocarbon-based solutions do not.

CORIOLIS

Coriolis meters provide mass-flow data by measuring fluid running through a bent tube, which is induced to vibrate in an angular, harmonic oscillation. Due to the Coriolis forces, the tube will deform, and an additional vibration component will be added to the oscillation. This causes a phase shift over areas of the tube, and this shift can be measured with sensors. Density measurements are made by analyzing the frequency shift of the vibrating pipe as the fluid flows past the pickup.

THERMAL MASS

Thermal mass meters utilize a heated sensing element that is isolated from the path of fluid flow. The flow stream conducts heat from the sensing element, and this heat is directly proportional to the mass flowrate. The meter's electronics include the flow analyzer, temperature compensator and a signal conditioner that provides a linear output, which is directly proportional to mass flow.

The electrical current required to maintain the temperature at the temperature sensor is proportional to the mass flow through the flowmeter. These flowmeters are commonly used in automobiles to determine the air density as it travels into the engine.

VORTEX SHEDDING

In this instrument, fluid vortices are formed against the meter body. These vortices are produced from the downstream face of the meter in an oscillatory manner. The shedding is sensed using a thermistor, and the frequency of shedding is proportional to volumetric flowrate.

TURBINE

Turbine meters incorporate a freely suspended rotor that is turned by fluid flow through the meter body. Since the flow passage is fixed, the rotor's rotational speed is a true representation of the volumetric flowrate. The rotation produces a train of electrical pulses, which are sensed by an external pickoff and then counted and totalized. The number of pulses counted for a given period of time is directly proportional to flow volume.

Turbine meters are used extensively to measure refined petroleum products, such as gasoline, diesel fuel or kerosene in custody-transfer applications.

POSITIVE DISPLACEMENT

Positive displacement (PD) meters separate liquid into specific increments. The accumulation of these measured increments over time is given as the flowrate. As the fluid passes through the meter, a pulse, which represents a known volume of fluid, is generated.

Some of the design types included in the positive-displacement flowmeter family include oval gear, rotary piston, helical, nutating disk and diaphragm flowmeters. In all design types, the fluid or gas forces a mechanical element, such as a set of gears, a disk, or a piston, to move within the primary device. For every revolution of a gear, or the complete movement of a piston or plate, a known volume of material is displaced.

ULTRASONIC

Ultrasonic meters operate by comparing the time for an ultrasonic signal to travel with the flow (downstream) against the time for an ultrasonic signal to travel against the flow (upstream). The difference between these transit times is proportional to the flow, and the flowmeter converts this information to flowrate and total flow.

They are particularly useful for measuring the flow of non-conductive fluids, such as solvents and hydrocarbons in large pipes — applications for which a magnetic flowmeter will not work. Ultrasonic flowmeters are also often used in district heating and chilled-water systems.

Doppler ultrasonic flowmeters have one transducer mounted at an oblique angle to the pipe. The transducer generates a signal into the fluid, which is reflected back from suspended particles or air bubbles.

Transit-time ultrasonic flowmeters have two transducers, likewise mounted at an oblique angle to the pipe, on opposite sides of the pipe. Alternating, one transmitter sends sound waves through the fluid to the other.

References

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