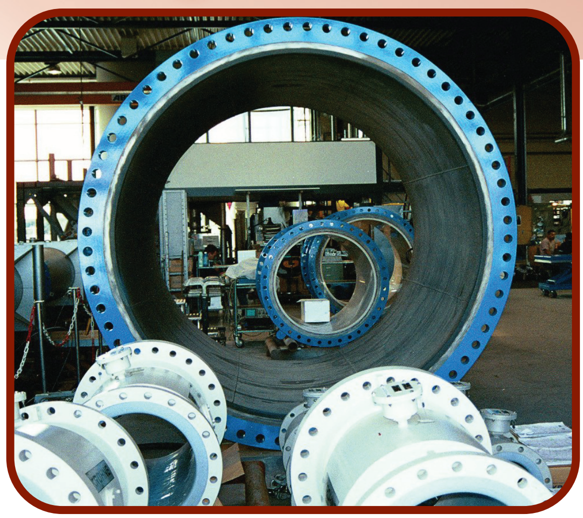
PRINCIPLE OF ATTRACTION

The Rise of Magnetic Flowmeter Technology

By Jesse Yoder



Magnetic flowmeters can support a wide range of pipe sizes.

The Tobinmeter Company first introduced magnetic flowmeters for commercial use in Holland in 1952. Foxboro (*www.foxboro.com*) introduced them in the United States in 1954. Since, more than 35 suppliers worldwide have entered the magnetic flowmeter market, and magnetic meters are now among the most widely used meter types for measuring the flow of water and other conductive liquids.

Magnetic flowmeters generate more revenues worldwide than any other meter type, including Coriolis, positive displacement, turbine, and differential pressure (DP) meters. The story is different, however, in terms of units. More positive displacement, turbine, DP, and variable-area flowmeters are sold annually than are magnetic flowmeters. Yet, because magnetic meters typically cost more than other flowmeter types, they account for more annual revenue.

Magmeters, as they are often called, are most widely used in the water and wastewater and chemical industries. These two sectors alone account for about half of the revenues generated by magmeters. Magmeters are also widely used in the food and beverage and pharmaceutical industries, which require flowmeters that can conform to sanitary requirements. And magmeters can be outfitted with sanitary liners to meet these demands.

Operating Characteristics

Magnetic flowmeters use Faraday's Law of Electromagnetic Induction. According to this principle, when a conductive medium passes through a magnetic field, a voltage is generated. This voltage is directly proportional to the velocity of the conductive medium, the density of the magnetic field, and the length of the conductor. In Faraday's Law, these three values are multiplied together, along with a constant, to yield the magnitude of the voltage.

Magnetic flowmeters use wire coils mounted within or outside of the meter body. A current is then applied to these coils to generate a magnetic field. As the conductive liquid passes through the body of the meter, a voltage is generated. This voltage is detected by electrodes, which are mounted on either side of the meter body. The flowmeter uses this value to compute flowrate.

Magnetic flowmeters are used to measure the flow of conductive liquids and slurries, including paper pulp slurries and black liquor. Their main limitation is that they cannot measure hydrocarbons, which are nonconductive. This makes them a bad fit for oil and gas and refining applications. Magmeters are, however, highly accurate and resistant to pressure drop.

The initial purchase cost for magmeters is comparable to vortex meters. They are more expensive than positive displacement and turbine flowmeters, but significantly cheaper than Coriolis and ultrasonic flowmeters.

Reasons for Popularity

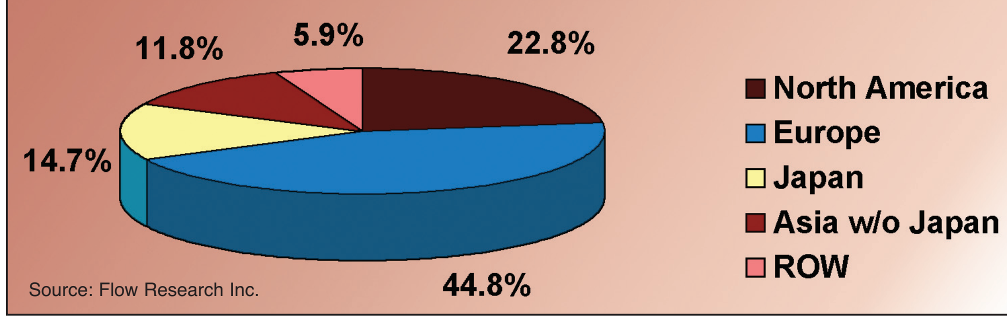
Magnetic flowmeters are widely used overseas. In fact, since they were first introduced in Holland, they have essentially become the flowmeter of choice in Europe. Part of the reason is because water is a highly valued resource in Europe, and magmeters are a good fit for water-based applications. The food processing and pulp and paper industries, where magnetic flowmeters are also widely used, are prevalent industries in Europe as well. And three of the top suppliers of magnetic flowmeters, Endress+Hauser (*www.endress.com*), Krohne (*www.krohne-mar.com*), and ABB (*www.abb.com*), are based in Europe. All of these factors contribute to the popularity of magnetic flowmeters in Europe.

Paradigm Case Application:

Magnetic Flowmeters

Every flowmeter has a paradigm case application that describes the conditions that the meter is ideally suited for. The paradigm case application for magnetic flowmeters is for conductive liquid flowing through a full pipe that does not contain materials that damage the liner or coat the electrodes. The most important limitation on magnetic flowmeters is that they do not work with nonconductive fluids. Since gases and steams are nonconductive, magmeters cannot be used to measure them. Also, magmeters compute flowrate based on velocity times area and typically require a pipe full of flowing liquid. Liner damage and electrode coating can affect the accuracy of magnetic flowmeters.

Figure 1. Shipments of Magnetic Flowmeters by Region (Percent of Dollars)



This is not to say that magmeters are not popular in the United States, but the domestic market is a bit less developed than it is in Europe (Figure 1).

Magnetic flowmeters also have some very important advantages, which have helped encourage uptake. Most magmeters are highly accurate, which is among the most prominent characteristics users look for in a flowmeter. Published accuracies for many magmeters are in the 0.5 percent range. In addition, magnetic flowmeters generate very little pressure drop. Insertion magnetic meters are an exception, but even here pressure drop is limited. Also, magmeters support a variety of liners that allow them to be used for a range of specific applications. Also, newer DC-type magmeters have eliminated the zero-calibration problems that AC-type meters experienced, which has further boosted their appeal.

Now, suppliers are finding ways to enable magmeters to measure lower-conductivity liquids. Some new magnetic flowmeters can measure liquids with conductivity below the five microsiemens/cm level. While it is unlikely that magmeters will ever be able to measure hydrocarbons, technological advances are making magnetic flowmeters usable in a wider range of applications.

Advantages

In an industrial environment that places a high value on reliability and accuracy, magnetic flowmeters are regarded as reliable and accurate devices. Magnetic flowmeters have significant advantages over traditional flowmeters. Magmeters do not rely on a primary element like DP meters (especially orifice-plate meters), which makes them less susceptible to wear and diminishing measurement accuracy over time. Further, magmeters do not have moving parts like turbine and positive displacement meters, which are prone to wear and unreliability as well.

Advantages and Disadvantages of Magnetic Flowmeters

Advantages	Disadvantages	Fluid Type	Size Range	Limitations
No obstruction in flowstream; No pressure drop; High accuracy; Does well on dirty liquids	Cannot meter nonconductive liquids (e.g., hydrocarbons); Medium to high initial cost; Electrodes can be subject to coating	Water and other liquids	1/10 inch to 100 inches	Limited use in the oil & gas and refining industries because it does not meter hydrocarbons; Minimum conductivity required

Magnetic flowmeters also have advantages over other new-technology meters. Magnetic flowmeters can be used in pipes of almost any size. Coriolis meters, on the other hand, become unwieldy and expensive to use in pipe sizes over three inches, and the majority are used on pipes of two inches or less. Also, magmeters hold an advantage over Coriolis meters when considering pressure drop. And they cost significantly less than Coriolis and ultrasonic meter types.

Application Notes:

When Magmeters Make Sense

The construction of the magnetic flowmeter is such that the only wetted parts are the liner and electrodes, both of which can be made from materials that can withstand corrosion. In addition, the strait-through (obstructionless) nature of the design reduces both the loss of hydraulic energy across the flowmeter (pressure drop) and the potential for abrasion from the flowing liquid. Therefore, magnetic flowmeters can measure many corrosive liquids and abrasive slurries.

Magnetic flowmeter liners and electrodes can be constructed of materials that do not contaminate the liquid. Therefore, these flowmeters can be applied when liquid contamination is an issue, such as in sanitary applications.

Straight-run requirements are relatively short, so magnetic flowmeter technology can be applied where limited straight-run is available. In addition, magnetic flowmeter technology has no Reynolds number constraints, so it can be applied where the liquid exhibits high or varying viscosity.

Magnetic flowmeters that sense velocity and level can measure the flow of liquids in partially filled pipes, such as interceptor sewers and stormwater culverts. Magnetic flowmeters with fast response times can measure liquids that flow for relatively short periods of time, such as in batch and fill operations.

Magnetic flowmeters measure liquid velocity, from which the volumetric flowrate is inferred. The measurement is linear with liquid velocity and exhibits a relatively large turndown. In addition, the range of accurate flow measurement is relatively large and easy to change after installation.

Replacing an existing two-wire instrument with a four-wire instrument typically requires the installation of an extensive amount of conduit/cable to provide power to the new instrument. Two-wire magnetic flowmeters that do not require power wiring can often replace an existing flowmeter using the existing wiring with little electrical rework.

Abstracted from The Consumer Guide to Magnetic Flowmeters, *by David W. Spitzer and Walt Boyes of Spitzer and Boyes LLC* (www.spitzerandboyes.com).

Disadvantages

Despite improvements in the minimum amount of conductivity required for measuring with magnetic flowmeters, the inability of magmeters to measure the flow of nonconductive liquids remains a barrier to wider use in certain industries. While they are used to measure water flow in the oil and gas and refining industries, the inability of magmeters to measure the flow of hydrocarbons severely limits their use in oil and gas applications. For example, magnetic flowmeters aren't receiving much uptake in the fast-growing flowmeter market for custody transfer of natural gas because they cannot be used to measure gas flow. This fundamental fact about magnetic flowmeters is not likely to change, even though meters have been developed that can measure liquids of minimal conductivity.

The coils in a magnetic flowmeter can be excited by either alternating current (AC) or direct current (DC). Alternating current meters typically have more problems with noise than direct current meters. They also can experience zero-calibration drift. On the other hand, some AC magmeters have greater signal strength than DC meters, and thus are better suited for use with dirty liquids and slurries. Today the bulk of magnetic flowmeters use DC technology, but AC technology remains an important part of the total magnetic flowmeter market.

Despite their drawbacks, the large installed base of magnetic flowmeters will sustain the markets strength going forward. Many companies have invested heavily in magnetic flowmeter technology and are not likely to abandon this investment for another type of meter. For this reason, magmeters will remain the proverbial king of the hill in the liquid flow measurement field, at least in terms of revenues, for the foreseeable future. FC

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