by Jesse Yoder, Ph.D.

Evolution of Magnetic Flowmeters

Technological Innovation Makes a Proven Meter Type More Useful

Magnetic flowmeters have emerged as an extremely popular method of flow measurement for a number of reasons, but most importantly because they excel in measuring most kinds of liquids. They are also relatively cost-efficient and straightforward to install. Further, with no moving parts, magmeters, as they're called, are easy to maintain and offer good accuracy for most applications.

In essence, magnetic flowmeters measure flow via magnetic coils powered by either alternating current (AC) or direct current (DC). When the current powers the coils, a magnetic field is created in the area of the flowing liquid. When conductive liquid flows through a magnetic field, a voltage is generated that is directly proportional to the velocity of the fluid. The magmeter detects this voltage using electrodes that are typically positioned on either side of the pipe and computes flow velocity based on the amount of voltage present.

From Continuous AC to Pulsed DC

Magnetic flowmeters were first introduced for commercial use in Holland in 1952 by The Tobinmeter Company. Foxboro (*www.foxboro.com*) released magmeter technology in the United States in 1954. Today there are more than 50 suppliers of magnetic flowmeters.

First-generation magnetic flowmeters were powered by continuous alternating current, which is subject to noise that interferes with the proper reading of the meter. As a result, continuous AC meters need to be regularly calibrated against an on-site hydraulic zero to compensate for the presence of noise.

DC magmeters were invented mainly as a solution to the zero-calibration issues associated with continuous AC magmeters. These magmeters operate based on a pulsed direct current. When the current is turned on, a voltage is generated, showing the velocity of the flowing liquid, plus any noise. When the current is turned off, any remaining voltage is assumed to be noise.

Figure 1. *EMCO Flow Systems' Unimag magnetic flowmeter is an example of a pulsed AC measurement system.*

By subtracting this voltage measurement, the meter provides a flow measurement that accounts for the effects of noise.

In addition, pulsed DC magnetic flowmeters use less power and have a lower coil excitation frequency than continuous AC magmeters. They also typically cost less than continuous AC magnetic flowmeters, because their design does not have to minimize the effects of eddy currents. Pulsed DC magmeters are also easier to install and cost less to operate than continuous AC magnetic flowmeters.

Pulsed DC magmeters became popular in the 1980s. Today, over 85 percent of magnetic flowmeters sold worldwide use pulsed DC technology, and about 90 percent of magmeter suppliers offer DC technology. Even so, close to one-third of magnetic flowmeter suppliers still offer some type of AC magnetic flowmeter, and some suppliers have both continuous AC and pulsed DC magmeters in their product line.

To compensate for the lower signal strength of many DC magnetic flowmeters, suppliers have developed high-strength DC magmeters. These high-strength meters employ the on-off current technology of other pulsed DC meters, but they produce a stronger signal. This stronger signal results from a higher coil current. As a result, these high-strength meters can handle high-noise applications, such as slurries and dirty liquids, better than other pulsed DC magmeters. Close to 25 percent of magnetic flowmeter suppliers today offer some type of high-strength pulsed DC magmeter.

Error Sources for Pulsed DC Meters

Even though pulsed DC magmeters dominate the market today, they still have their limitations, especially for slurries and other liquids containing solids. Two potential sources of error for pulsed DC magmeters are media noise and liner and electrode seal microporosity. Both of these sources of error can interfere with the integrity of the flowmeter signal and its ability to provide fast response with good accuracy.

There are multiple sources for media noise (see sidebar). These include entrained magnetically charged particles, solids impacting against the electrodes, low- and variable-media conductivity, and coated electrodes. Liner and electrode seal microporosity refers to the possibility that media molecules can migrate past the electrode seals or through the liner itself. Liner microporosity normally results from wear or large temperature differentials across the liner. Electrode microporosity emanates from minute liner and seal movements due to shock or variation in temperature or static pressure.

Pulsed AC Magmeters

While pulsed DC technology has a number of advantages, AC magmeters maintain advantages for certain applications. The strength of the current exciting the coils is

What Causes Media Noise?

- Electro-chemicals (e.g. Hydrogen ions +ve, hydroxyl ions –ve)
- Entrained magnetically charged particles
- Solids/particulate impact against electrodes (piezoelectric)
- Frictional effects against electrodes — fibers, etc. (triboelectric)
- Low and variable media conductivity
- Coated electrodes

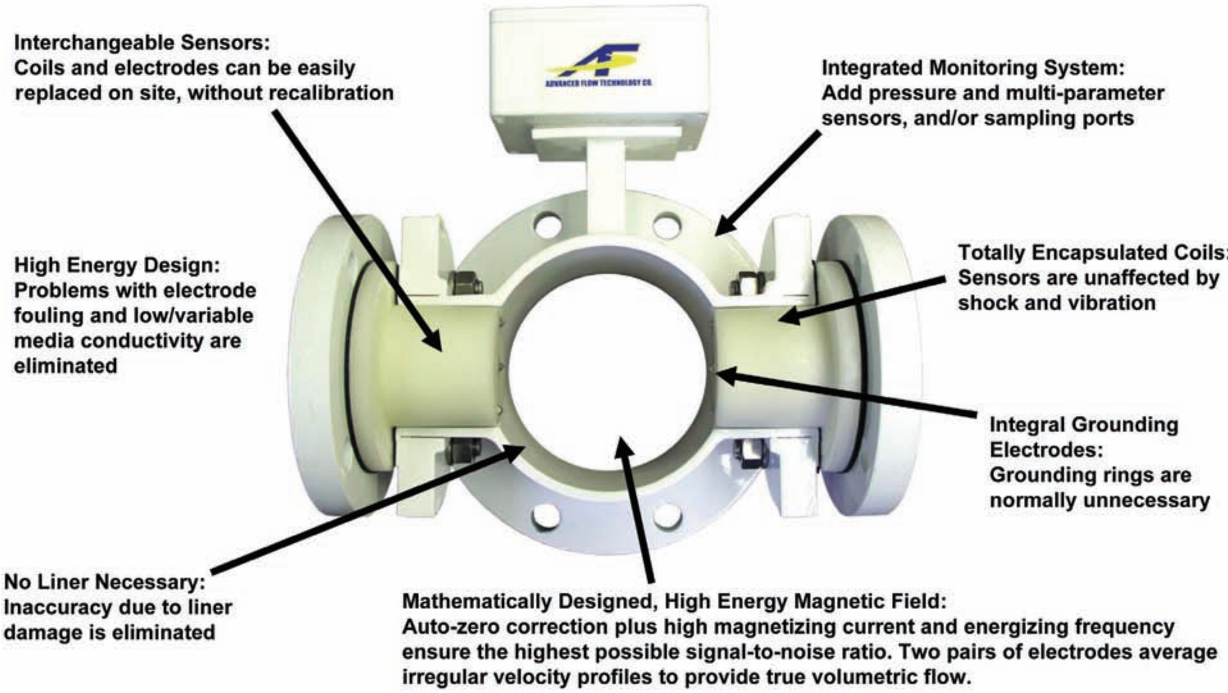

Figure 2. *The Unimag's solid-state sensor is designed to eliminate liner and electrode seal microporosity and substantially reduce the effects of media noise.*

typically less in DC magmeters than in AC magmeters. Consequently, AC magmeters have very good signal strength and relatively high exciter frequency, which makes them suitable for slurries, pulps, and other noisy media. The combination of relatively high exciter frequency, typically greater than 30 Hz, and exciter coil current, typically in the amps regime, significantly improves signal quality by producing a strong, noise-free signal.

To counteract the disadvantages of continuous AC magmeters, while retaining some of the advantages of pulsed DC meters, some suppliers have introduced pulsed AC magnetic flowmeters. One such company is Siemens Energy & Automation (*www.siemens.com*), which sells the Transmag 2. Another company is EMCO Flow Systems (*www.emcoflow.com*), which manufactures the Unimag (Figure 1). EMCO refers to its technology as "pulsed hybrid."

This meter has an auto-zero feature and compensates for eddy currents, even at relatively high exciter frequencies up to 40 Hz. It has a strong exciter current in the amps regime, together with a typical exciter frequency of 40 Hz, making it a good choice for slurries, pulp, dirty, and clean media.

Another EMCO design features a magmeter without a liner. Electrodes, exciter, and reference coils are contained in a removable solid-state insulated sensor, positioned on either side of the flowtube. The large ratio of sensor diameter to flowtube diameter, as well as a plurality of sensors and a magnetizing current in the amps regime, gives this design the same hydraulic accuracy as a conventionally designed continuous AC or a pulsed DC meter. For media with very thick coatings, optional extended electrodes are made long enough to protrude through the media coating. This solid-state sensor design eliminates liner and electrode seal microporosity and substantially reduces the effects of media noise (Figure 2).

Balancing the Benefits of AC vs. DC

Magnetic flowmeter technology has come a long way since 1952. Like other flowmeter types, magmeters have gone through a technological evolution, with many new innovations and improvements designed to compensate for previous disadvantages. Pulsed DC magmeters were introduced to counter the calibration and power issues of early-generation AC magmeters and have become the dominant technology. Now pulsed AC magmeters retain some of the benefits of both continuous AC and pulsed DC designs. However, no technology is perfect for all applications.

Despite all the advances made by magnetic flowmeter suppliers, no one yet has figured out how to enable magmeters to effectively measure the flow of hydrocarbons, whose conductivity is usually very low. Magnetic flowmeters also cannot measure the flow of gas or steam. But suppliers have made advances in enabling magmeters to measure liquids with lower conductivity levels, and they have also significantly increased accuracy. Look for suppliers to continue to bring out new features and products as they deal with the unique challenges posed by magnetic flow measurement. FC

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