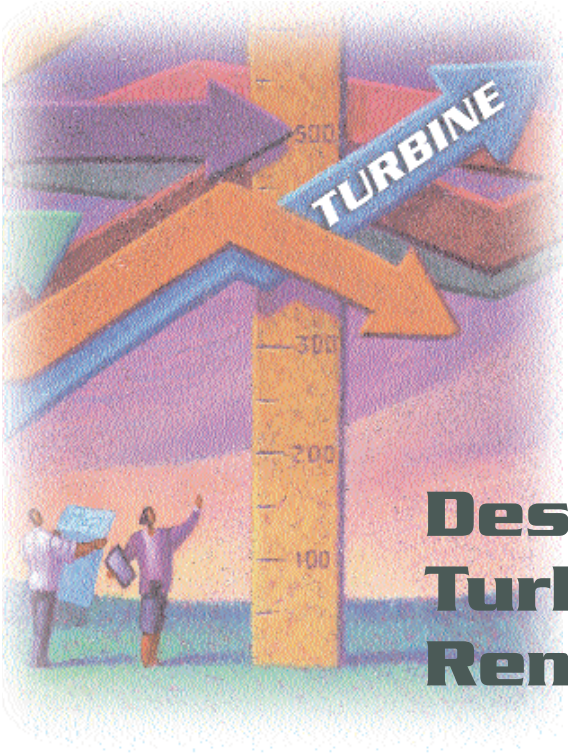


There are still some applications where turbine meters remain the best flow solution. Given their very large installed based and technological improvements being made by the suppliers, turbine flowmeters will be around for many years to come.

Despite Market Declines, Turbine Flowmeters Remain Major Segment

By Dr. Jesse Yoder

Turbine flowmeters have been around for many years. In fact, the generally accepted view places the invention of the first turbine meter in 1790. However, it wasn't until World War II and afterwards that turbine meters began being used in industrial environments. And even though turbine meters are facing competition today from new technology flowmeters, the turbine market is still very large and is growing in some segments.

The word "turbine" is derived from a Latin word that means "spinning thing." The ancient Greeks ground their flour using horizontal turbine wheels. However, the idea of using a spinning rotor or turbine to measure flow did not come about until much later in history. And this is what turbine meters have in common, the use of a rotor that spins in proportion to flow rate.

History and Types

Reinhard Woltman is generally credited with the invention of the first turbine flowmeter in 1790. Woltman was a German engineer who studied the loss of energy in open canals. He published several works on hydraulic engineering in the 1790s. Today's bulk meters, used to measure water flow in larger quantities, are still called Woltman flowmeters.

There are at least eight distinct types of turbine flowmeters. Some turbine meters get their name and inspiration from types of water wheels. Others are mainly used to measure the flow of water for billing purposes. The types of turbine meters are as follows. (See *Types of Turbine Meters*, page 54.)

- Pelton wheel
- Paddlewheel
- Propeller
- Woltman
- Single jet
- Multi-jet
- Compound
- Axial

What turbine meters have in common is the use of a rotor that spins or rotates in proportion to the flow rate. Measuring flow in this way requires the capability of detecting the rotational speed of the rotor. For this reason, the turbine meter as it is used today had to await the invention of a pick-off sensor with a magnet and a rotating conductor. This makes it possible to count the number of rotations of a turbine rotor. In the early 1940s, turbine meters were developed to accurately measure fuel consumption on military aircraft in World War II. Soon after this time, turbine meters began to be used to measure the flow of hydrocarbons.

The use of turbine meters to measure gas flow dates back to 1953. Rockwell introduced an improved turbine meter to the gas industry in 1963. It took about 10 years for turbine meters to become accepted by the gas industry for measuring gas flow. In 1981, the American Gas Association (AGA) published its report #7, *Measurement of Fuel Gas by Turbine Meters*. Since that time, turbine meters have been solidly established in the gas industry, especially for custody transfer applications.

Where they are Used

Turbine flowmeters are mainly used to measure the flow of fluids in the following four segments.

- Municipal water
- Municipal and industrial gas
- Oil (hydrocarbons)
- Industrial liquids

Turbine meters used in the municipal water industry are widely used for billing purposes. Some turbine meters are used for residential billing purposes, especially single jet and multi-jet

meters. However, nutating disc and oscillating piston positive displacement meters dominate this market. Because turbine meters excel at medium- to high-speed flows, they are used more widely for billing purposes in commercial and industrial markets. In this use, they are sold to water and gas utility companies that install them in commercial and industrial buildings to measure the amount of water and gas used in those buildings.

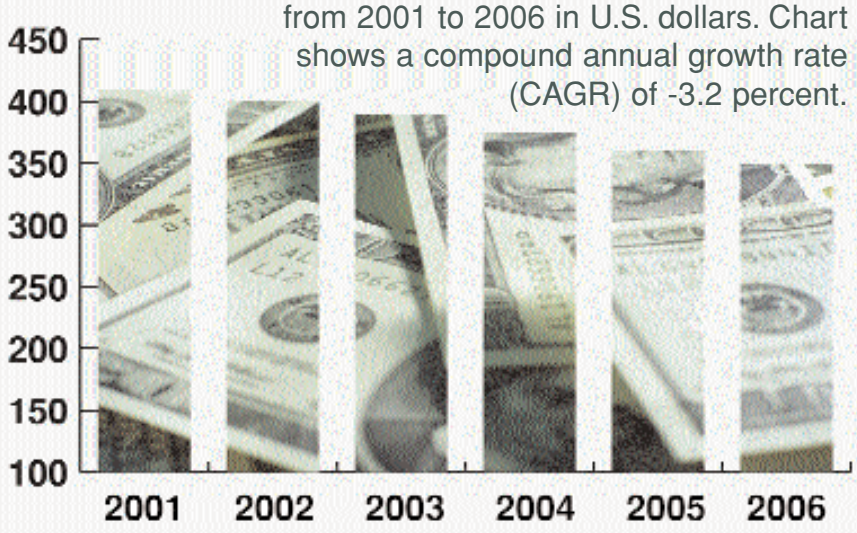
Many manufacturing plants measure liquids and gases inside of the plant as part of the manufacturing process. These are considered to be industrial applications. However, the water and gas that these plants use, when it is obtained from a water or gas utility company, has to be measured for billing purposes. This is considered to be a utility application and is very similar to the measurement of gas or water used by a hotel or office building.

Besides being used for utility gas measurement, turbine meters are also used for industrial gas measurement. The use of turbine meters to measure natural gas for custody transfer purposes is an example of industrial gas measurement. A number of companies sell into the turbine gas flow market, including Invensys, Elster, Instromet and Emerson Daniel.

Another important segment of the turbine flowmeter market is the market for measuring hydrocarbon-based liquids. Both turbine and positive displacement flowmeters are used to measure the flow in this segment. Turbine meters are used to measure the transfer of hydrocarbons in trucking, aviation, petroleum transportation, petroleum production and petroleum terminals. These meters are very different from the smaller jet type meters and are highly accurate and rugged industrial meters. They are used because of their accuracy and their reliability.

Turbine meters are also used to measure the flow of industrial liquids. This measurement can occur within a manufacturing plant, or it may occur as a custody transfer operation between plants. Chemical, food processing, refining and power plants are examples of some of the manufacturing plants that use turbine flowmeters.

Figure 1

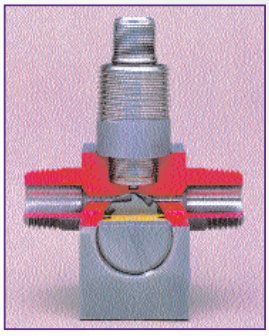


Turbine Flowmeters Still a Viable Choice

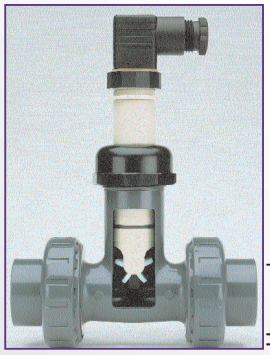
Turbine meters belong to the class of traditional technology flowme-

Types of

Pelton wheel. The origins of the Pelton wheel flowmeter go back to a type of water wheel called the Pelton wheel. Lester Pelton (1831–1908) built the first Pelton wheel water wheel in Camptonville, CA. A Pelton wheel turns as a result of water jets that impinge on buckets attached around the outside of the wheel. The wheel is connected to a turbine. The turning of the wheel rotates the turbine and generates power. Lester Pelton formed the Pelton Water Wheel Company in 1898. Today Pelton wheel flowmeters are used to measure low viscosity flows at low flow rates.


Sponsler

Paddlewheel. Paddlewheel flowmeters are also based on the design of a water wheel. Paddlewheel meters have a shaft at right angles to the flow stream. They have a lightweight paddlewheel that spins in proportion to flow rate and are used to measure low-speed flows. Paddlewheel flowmeters are available in both insertion and inline types.


Hayward

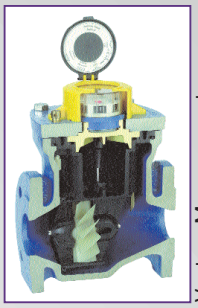
Propeller. The origins of the propeller meter go back to the invention of the propeller turbine, which is used for hydropower. Forrest Nagler designed the first fixed-blade propeller turbine, which was installed in 1916. The propeller turbine has from three to six blades and resembles the propeller on a boat. Because propeller turbines have fewer blades than some other turbines, they are less likely to be damaged by debris in the water.

Today's propeller meters are based on a similar principle. Propeller meters face into the flow and have a single bearing assembly. While some people do not consider propeller meters to be a type of turbine meter, they have a rotating element whose rotation is proportional to flow rate. Propeller meters are relatively low cost and do not require power.

Woltman. Woltman meters have a turbine whose axis is

ters. The history of new technology flowmeters begins after 1950, while the origins of traditional technology meters predate 1950. Many traditional technology meters have moving parts and some are mechanical rather than electronic. New technology flowmeters include Coriolis, magnetic, ultrasonic, vortex and multi-

Turbine Meters

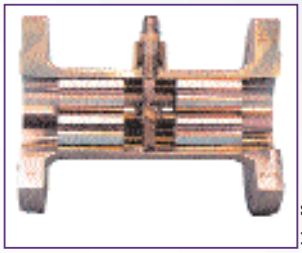

Venture Measurement

in line with the direction of flow. These meters are used in the municipal and industrial water industry to measure larger flows. They are sometimes called "bulk" meters. Their name goes back to Reinhard Woltman, who invented the first turbine flowmeter in 1790.

Single jet. Single jet meters are widely used in residential and commercial applications to measure the flow of water for billing purposes. In single jet meters, water passes through an orifice, creating a stream or "jet" of water. This jet of water is directed onto the impeller blades, causing them to rotate.

Multi-jet. Like single jet meters, multi-jet meters are used in residential and commercial applications to measure the flow of water for billing purposes. Some are also used in industrial applications. Multi-jet meters have several orifices creating several jets that are directed onto impeller blades, causing them to rotate.

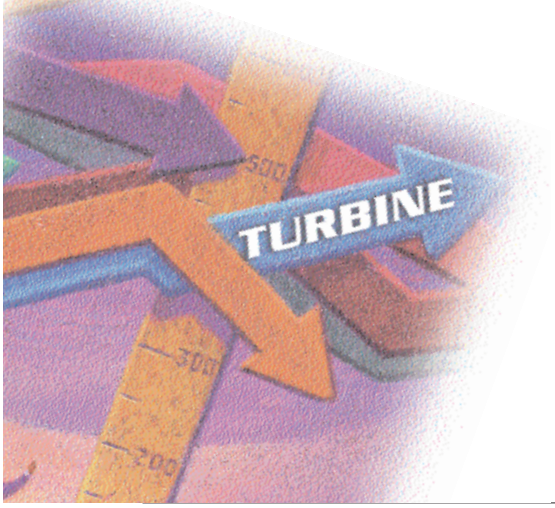
Compound. Compound meters are a type of hybrid meter that have a turbine component. Compound meters are installed in apartment buildings and offices where the flow rate varies between high and low flow rates. Flow rates might be very high in apartment buildings in the morning and evening, for example, but be very low or nonexistent at night. Compound meters typically have a turbine component to handle high flow rates and a positive displacement component to handle the low flow rates. They may also have a single jet or multi-jet turbine for the lower flow rates.


Hoffer

Axial. Most of the turbine flowmeters used in industrial applications to measure the flow of hydrocarbons, industrial liquids and gases are called axial turbine meters. Axial meters have a rotor that rotates around the axis of flow. Axial meters differ according to the number and shape of the rotors. Axial meters for liquids have a different design from axial meters for gases.

variable differential pressure (DP). Traditional technology flowmeters include differential pressure, turbine, positive displacement, open channel and variable area.

There is a clearly identifiable trend today towards new technology flowmeters and away from traditional technology meters. However, despite this trend, there are sev-



eral reasons why traditional technology meters are still extremely important in today's flowmeter market. One reason is that some of the traditional technology flowmeter markets are so large that even if they are showing a slight decline, these meters still represent a very large volume of business every year. (See Figure 1, page 53.) For example, the worldwide turbine market exceeded $400 million in 2001.

Secondly, traditional technology meters still have a very large installed base. This is certainly true of turbine meters. Turbine meters are very well entrenched in gas flow measurement, in hydrocarbon liquid measurement and in the municipal water market. Because end users often replace like with like, many of them will continue to use turbine technology for many years to come.

Third, in some cases, traditional technology flowmeters really are the best solutions for certain types of flowmeter applications. For example, it is difficult to find any flowmeter that handles low flow rates and high viscosity fluids as well as positive displacement flowmeters. And turbine meters excel at measuring the flow of clean medium- to high-speed liquids and gases. They are still widely used for this purpose.

Turbine meters also do not have some of the limitations that some new technology meters have. For example, turbine meters do not have the same line size constraint that limits the use of Coriolis meters to four inches and less, with a few exceptions. They can also meter hydrocarbons, unlike magnetic flowmeters. The main competitor to turbine flowmeters, especially in the larger sizes, is ultrasonic flowmeters. This is especially true for natural gas flow, where ultrasonic flowmeters received AGA approval in 1998 for use in custody transfer of natural gas. DP flowmeters are also widely used in this context.

Turbine flowmeter manufacturers are also coming out with improvements that make these meters more reliable and more competitive with new technology meters. For example, Hoffer Flow Controls has introduced turbine meters with hybrid ceramic ball bearings, thereby increasing the reliability of their meters. Bopp & Reuther is selling a HART-compatible turbine flowmeter. It is likely, in fact, that more suppliers will incorporate

features from new technology flowmeters into turbine meters in the future, such as advanced electronics, making them both more reliable and better able to fit into today's more advanced instrument marketplace.

Another reason why traditional technology meters are holding their own or growing in some segments is that industrial associations play a major role in determining what meters are acceptable in some applications, especially for billing purposes. And in some cases, traditional technology meters are all that is specified. Until new technology flowmeters receive approvals from the standards bodies and industry associations, traditional technology meters will continue to be used.

In the United States, for example, the American Water Works Association (AWWA) is very influential in laying out criteria for water meters to conform to when they are used for billing purposes. The AWWA has written reports approving both turbine and positive displacement flowmeters for this purpose. The AWWA has formed a committee to study issuing a report for magnetic flowmeters, but such a report is still several years away. The organization is also looking at the possibility of forming a committee for Coriolis meters, but has not yet done so. In the meantime, single jet, multi-jet, Woltman and positive displacement meters dominate the municipal water industry.

Conclusion

There are many types of turbine flowmeters and they are used for many different applications. Even though the turbine market as a whole is showing a slow decline, some segments are experiencing growth, especially in areas where new technology flowmeters have not yet penetrated. There are still some applications where turbine meters remain the best flow solution. Given their very large installed based and technological improvements being made by the suppliers, turbine flowmeters will be around for many years to come. FC

About the Author

Dr. Jesse Yoder is president of Flow Research, which he founded in 1999. He has been a writer and analyst in process control since 1986. Yoder has written over 40 market studies and is currently completing a 12-volume series of studies on the worldwide flowmeter market. Included in this series is The World Market for Turbine Flowmeters, *which was released in September of this year. Flow Research* (www.flowresearch.com) *offers a quarterly update service called the* Worldflow Monitoring Service. *You can contact Dr. Yoder at 781 245-3200, or* jesse@flowresearch.com.