Pharmaceutical MANUFACTURING

GETTING THE MOST FROM CORIOLIS **FLOWMETERS**

The tradeoff between accuracy and drainability helps determine the selection

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CORIOLIS flowmeters measure flow directly, by taking advantage of the Coriolis effect. Simply stated, the inertial effects caused by a fluid flowing through a tube are directly proportional to the mass flow of the fluid. In a Coriolis flowmeter, vibration is induced in the process-filled flow tube(s), with the mass flow rate captured by measuring the time delay between the inlet and the outlet of the sensor.

These meters also provide a direct and independent density measurement, which is proportional to the vibrational frequency of the tubes. As the process fluid becomes denser and heavier, the vibrational frequency of the flow tubes decreases.

There are two basic styles of Coriolis flowmeters: (Dual) bent tube and (single) straight tube.

Bent-tube meters offer accuracy and turndown benefits. In the bent-tube design, two bent tubes in the flowmeter are vibrated relative to one another. This vibration produces a sinusoidal motion along the length of both flow tubes. This motion is measured at the inlet and outlet of the sensor. The Coriolis effect produces a time delay between the motion at the inlet and outlet that is directly related to mass flow rate.

Straight-tube meters are more rigid than their bent counterparts, so they are somewhat less sensitive. However, these devices offer improved drainability. In the straight-tube design, the single flow tube is vibrated relative to an external reference tube. The two pieces move in opposite directions, and, as with the dual tube device, the motion at the inlet is compared to the motion at the outlet and the time delay between them is a direct measure of mass flow rate.

Coriolis flowmeters can be used in many areas of pharmaceutical manufacturing. A particular strength of the technology is the fact that it isolates the process. The only part of the flowmeter that comes in contact with the process is the inside of the flow tubes, which are made of corrosion-resistant metal alloys. There are no fluids or parts that can be exposed to the process in the event of device failure.

CLEANABILITY AND DRAINABILITY

Most applications in pharmaceutical manufacturing require a high level of cleanability. When systems are cleaned in place, drainability is required.

The flow tubes within Coriolis meters feature all-welded metal surfaces, free of any crevices or synthetic materials that can absorb process chemicals.

While some bent-tube flowmeters drain well if they are oriented carefully, others do not drain well no matter how they are installed. If drainability is critical and the higher accuracy of a bent-tube meter is also required, it is critical to work closely with the device's manufacturer. System drainability and meter performance, or both, can be compromised depending on the orientation of the tube bends. For example, low points can trap liquids and solids, while high points can trap gases.

Straight-tube Coriolis flowmeters can be oriented in virtually any direction. When installed in vertical process piping, the flowmeter is fully drainable; but the flow also should be up through a vertically installed meter. If installed in horizontal process piping, straight-tube meters must be sized and installed carefully. The ASME BPE-2005 Bioprocessing Equipment Standard, Part SD-3.12.1, provides guidance for ensuring full system drainability in horizontal piping and in-line measurement equipment.

In some applications, accuracy and repeatability are paramount to success. In others, unrestricted flow is the critical factor. The accuracy of a straight-tube Coriolis meter is determined by the material of construction and the sensitivity of the components used to measure time delay. At any flow rate, the sensitivity (accuracy) decreases as the sensor tube's inside diameter increases.

The smallest working sensor for many installations may be a full pipe size smaller than the process piping. As a result, the flowmeter can create a significant pressure drop in the system. It is up to each operating company to determine whether accuracy or pressure drop is most important. The smaller tube will be able to measure lower flows than the larger tubes. The larger sensor will reduce piping system drain time.

RULES OF THUMB

Following are some rules of thumb for selecting Coriolis flowmeters in specific types of operations.

API Synthesis and Purification

There are numerous opportunities for flow measurement devices during the chemical synthesis phase of production. Often, large quantities of raw materials must be received from vendors and accounted for as they enter the chemical synthesis process. There can be many dif-

ferent kinds of flow measurement devices scattered throughout the receiving phase.

- Bent-tube Coriolis flowmeters are desirable wherever highly accurate, reliable and rangeable mass flow or density measurement is needed.
- Straight-tube Coriolis flowmeters are preferred when raw-material contamination is a concern. Between runs of the same material or between runs of different materials it may be necessary to ensure that no cross-contamination can occur.

Fewer flowmeters are involved in API purification processes, but Coriolis technology offers superior overall measurement accuracy, repeatability, multivariable capability and pharmaceutical-friendly materials of construction. When accuracy is secondary to drainability (about half of the time) straight-tube meters should be used. Otherwise, bent-tube meters offer high performance and repeatability characteristics.

The straight-tube Coriolis flowmeter, such as the T series meter shown here, offers enhanced drainability. Photo Courtesy of Emerson Process Management

Pharmaceutical Formulation

Formulation also offers opportunities for using Coriolis flowmeters. In this case, cleanliness is paramount, and the more accurate bent-tube Coriolis flowmeter is a better choice. However, for fixed piping systems that are cleaned in place, the straight-tube type is preferred.Where disposable piping systems are used, the bent-tube flow meter may be the better choice.

High Purity Water

Using a Coriolis flowmeter to measure the flow rate on a simple distribution loop is unwarranted when an adequate, less expensive technology like a vortex flowmeter is available. However, Coriolis flowmeters can be used effectively in high purity water and water-for-injection (WFI) applications. To monitor the use of high purity water, two straight-tube meters on a loop may replace a flowmeter at each point of use. This can save considerable money and improve the overall accuracy of total water usage.

Users often complain that a totalized water flow rate is erratic when the water line must be completely drained. This is the case whether vortex, magnetic or Coriolis technologies are used. However, in such cases, maintaining two flow sensors that are kept full produces consistent results.

Coriolis flowmeters are more expensive than most other flow measurement technologies. However, the flowmeters' additional cost is offset by the following factors:

- Accuracy specifications from 0.5-100% of range, which allow for setpoint optimization without replacing a flow sensor.
- Lack of any internal fabrication joints, a polished interior and, with the straight-tube type, a design that facilitates cleaning and draining.
- All-metal surfaces, which eliminate the risk of leachables and particulates breaking down synthetic materials of construction.
- Process containment
- A direct mass flow rate or total.

Alternate technologies are generally preferred when the flow rate to be measured is kept within a small range or is volumetric and the process fluid is of a consistent density.

OVERCOMING TRANSIENT FLOW

Recently, much attention has been paid to the difficulties associated with transient flow, which include two-phase flow, entrained gas, slug flow, empty-fill-empty and flashing. Generally, transient flow refers to processes in which there is continuous or intermittent mixture of gas, liquid and/or solids. In pharmaceutical manufacturing, the high degree of batch processing coupled with cleaning practices often leads to situations where a flowmeter will start empty, be filled and then emptied again by design. In addition, poor hydraulic design in piping can lead to gas entrapment and entrained gas flow. Virtually any flow measuement technology, including Coriolis flowmeters, can suffer unacceptable levels of error when subjected to significant transient flow. However, hardware and software-based solutions can reduce the impact of transient flow on Coriolis flowmeters. In processes where the transients are known, it is best to consult with the flowmeter manufacturer.

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