Technical Publication

Flow Measurement and Control For Small Line or Batch Processes

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The measurement and control of air, gases and liquids in small line and batch processes is critically important. In many processes, these measurements are essential to achieving the best final product quality, with the highest yield and at the lowest cost. Today's sophisticated processes often require highly precise flow measurement — down to considerably less than 1 ounce in liquids and much less than 1 SCFM in gases.

Understanding Flow Sensing Technologies

When selecting a flow sensor, flow meter, or flow switch for your small line or batch process, one of the first considerations is always the process media: air, gas, steam or liquid. Some flow sensing technologies measure gas, some are better at liquids, some are best for a single media, such as steam, and others are good in multiple media. The industry's major flow sensing technologies now available include:

- Coriolis (Mass)
- Differential Pressure
- Electro Magnetic
- Positive Displacement
- Thermal (Mass)
- Turbine
- Ultrasonic
- Variable Area
- Vortex Shedding

Depending on the process media and your application's requirements, all of these technologies have their advantages/disadvantages. By considering the process media to be measured, as well as your plant's equipment and layout, environmental conditions, maintenance schedules, energy cost and ROI, you will be able to narrow the field to one or two best choices.

Typical Small Line or Batch Process Applications

Small line and batch process operations are common in many industries, including chemical processing, food/beverage, pharmaceutical and others. Some typical examples of how the measurement and control of air, gas and liquids supports small line and batch process operations in these industries include:

- Air flow monitoring in cheese production
- Ingredient monitoring and control in juice processing
- Low flow monitoring and switching in beverage bottling

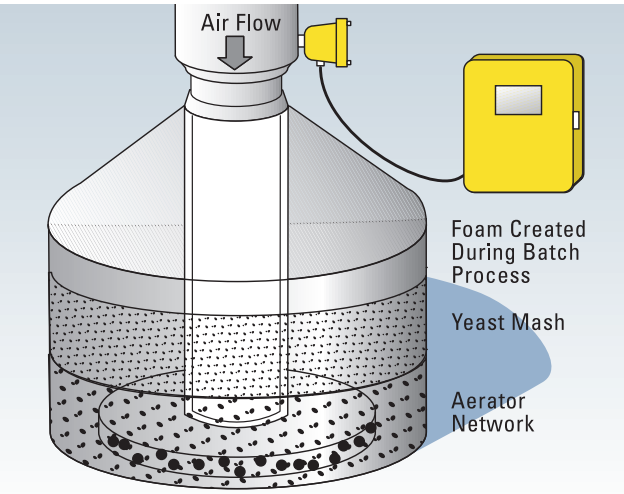

Figure 1. Air Flow for Yeast Growth

- Hydrogen gas flow monitoring in pharmaceutical production
- Nitrogen tank blanketing/monitoring in chemical plants

Air Flow for Yeast Growth. Food processors require air flow measurement to ensure the quality of many products. For example, the yeast in cheeses requires accurate air flow measurement to provide proper growth. In cheese production, an air flow meter (Figure 1) is often installed on the air inlet line to the cheese batching vessel to monitor and control inlet air flow and temperature. A 4-20 mA output provides process data to a programmable controller or plant distributed control system.

Liquid Flow Metering in Juice Processing. In the production of fruit juices and related food products (such as nectars, beverage cocktails, juice bars, etc.), the careful flow measurement of water, sweeteners and other ingredients is essential for flavor, clarity and shelf-life (Figure 2). Liquid flow meters and switches accurately measure and control small quantities of ingredients with high precision and high repeatability.

Liquid Flow Switching for Beverage Bottling. In beverage bottling operations, there are many critical applications that depend on a reliable indication of liquid flow. These include preventing carbon dioxide gas addition, stopping the bottling line or shutting down chillers or refrigerant upon the loss of product flow (Figure 3). Inline switches are installed at specific points in the process line to control liquid flow and level, which ensures that the line operates at maximum efficiency.

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Hydrogen Flow Monitoring for Pharmaceuticals. Measuring hydrogen flow to a hydrogenization reactor is crucial in the production of various pharmaceutical products. Reduced hydrogen consumption in the process is a critical indication of the completion of the batching process. Flow meters on hydrogen lines measure gas flow during the peak high demand portion of the process and the low demand cycle that signals the end of the batch process (Figure. 4).

Nitrogen Gas Tank Blanketing. A wide variety of processes employ nitrogen tank blanketing to avoid the emission of toxic or combustible fumes and to prevent fires or explosions. A low pressure "blanket" of inert gas, usually nitrogen, is injected into the vapor space of a storage tank above the liquid held in the tank (Figure 5). A flow meter is typically utilized to monitor and control the flow of nitrogen gas into the tank. Flow switches are also placed on tank relief valves, which detect a fully open valve or partially closed valve that is resulting in a leak.

Matching Flow Instruments To The Process

When looking at any flow measurement and control technology, after you consider the media, there are several other factors to always consider:

- Line size and accuracy
- Calibration method
- Installation environment
- Maintenance needs
- Instrument life
- Lifecycle cost
- Physical installation constraints and complexity

It is important to know the flow range, accuracy and repeatability of a flow sensor, flow meter or flow switch. For example, a standard small line Coriolis flow meter, such as those manufactured by Micro Motion, Endress+Hauser, FCI, and others, measures liquid flows in line sizes from 1/8 to 3.0 inches over a wide range from as little as 0.07 to 2205 pounds per minute (20 to 60,000 kilograms per hour) with accuracies from +0.1 to 0.5% percent reading. (Figure 6).

Will the flow sensor be calibrated with the actual media that you plan to flow? This can be important, especially in gases. There can be substantial differences in calibration integrity using a theoretical air equivalency method versus an actual gas method that can lead to costly post installation problems. Only a very few flow sensor manufacturers maintain their own flow calibration laboratories in order to provide exacting calibrations to specific gases and gas mixture concentrations to achieve the most accurate flow measurement.

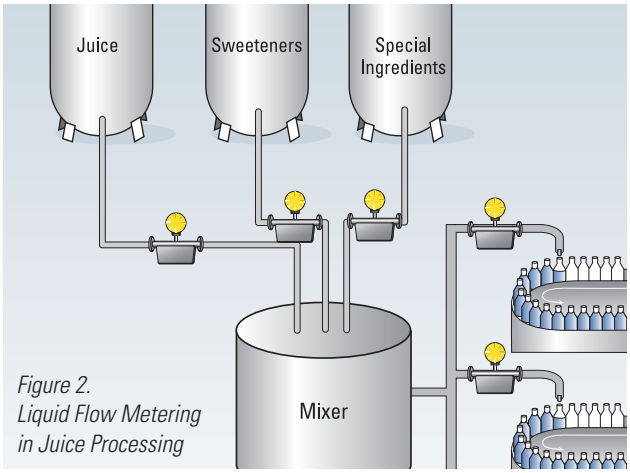

Figure 2. Liquid Flow Metering in Juice Processing

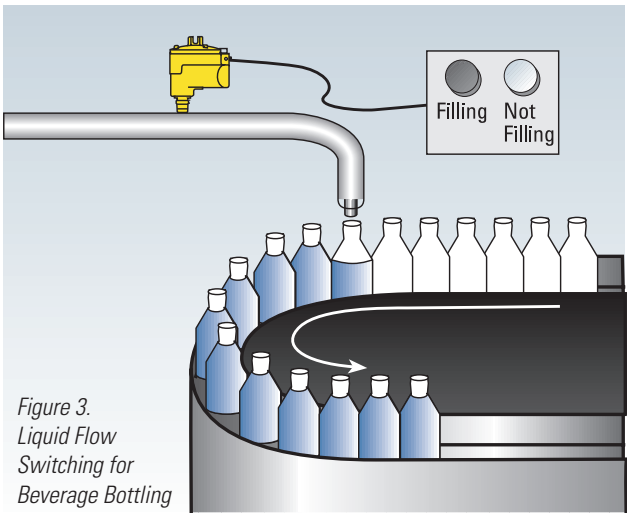

Figure 3. Liquid Flow Switching for Beverage Bottling

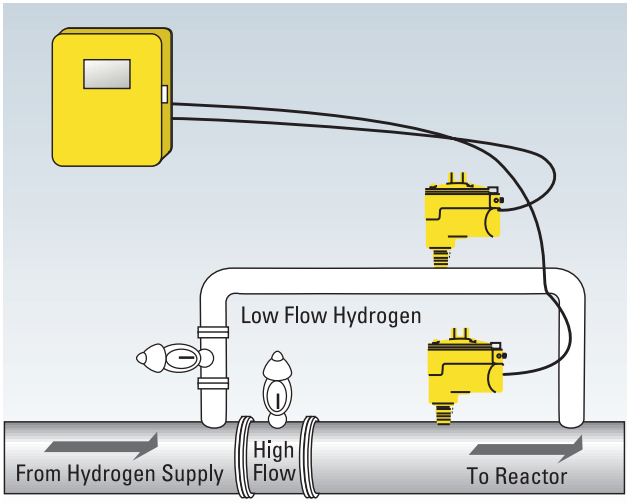

Figure 4. Hydrogen Flow Monitoring for Pharmaceuticals

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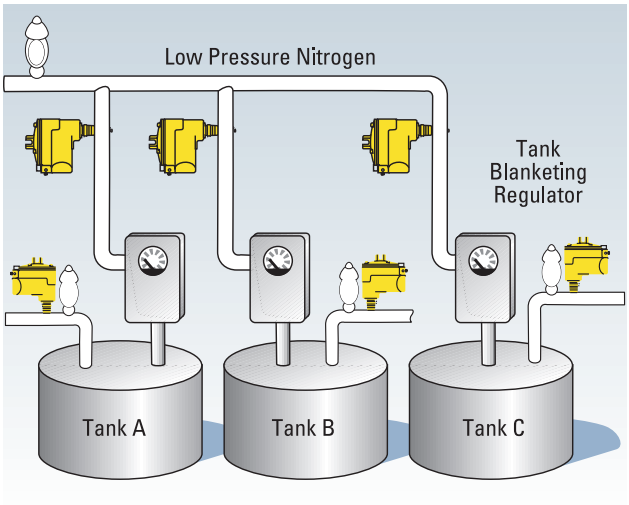

Figure 5. Nitrogen Gas Tank Blanketing

Figure 6. FCI Coriolis Flow Meter

The flow meter's wetted materials of construction and any moving parts are a vital to ensuring fluid compatibility and service life. Acidic or caustic fluids can rapidly erode steel pipes and mechanical flow meter elements. In addition to the normal fluid, do not overlook compatibility with cleaning fluids. The longest service life and lowest total investment may be achieved only by flow meters technologies with no moving parts and/or constructed of more exotic wetted materials such as Hastelloy, Monel, Tantalum, etc.

In addition to the sensor element itself, the instrument's transmitter packaging and electronics housing are important to match to ambient installation environment Indoor, climate-controlled, and clean environments may be fine with plastic housings for a flow sensor, flow meter or flow switch. However, in process environments that get dirty, have dust or airborne particulates, exposure heat, cold, or humidity, a rugged metal package with an appropriately rated NEMA/IP enclosure will ensure proper operation and reduce maintenance.

After you've considered the process media, the line size, desired accuracy, the ambient installation environment, you'll want to think about physical installation requirements. Consider how much space is required, accessibility of the installation location, whether there are flow profile disturbers such as valves or elbows in the pipe run. A number of flow metering technologies, for example, require a specific number of straight pipe run diameters before and after the meter to ensure a stable and fully developed flow profile for accurate measurement.

Some manufacturers, such as FCI and others are designing new flow meters with built-in flow conditioners (Figure 7). Flow conditioners, which solve both swirl and velocity profile disturbances, can actually reduce the pipe straight-run requirement by up to 70 percent to achieve the specified measurement accuracy.. In many crowded equipment layouts, the space-savings achieved with a reduction in piping materials and labor, as well as the higher accuracy performance, can actually result in a cost savings.

Optimizing Your Process

The careful selection of flow instrumentation for your small line or batch process will result in improvements to product quality, consistency, throughput and the lowest installed cost. The value of raw products or other ingredients, as well as material waste, energy—even end-customer satisfaction--all can be influenced by the precise measurement of air, gas, steam and liquid. ■

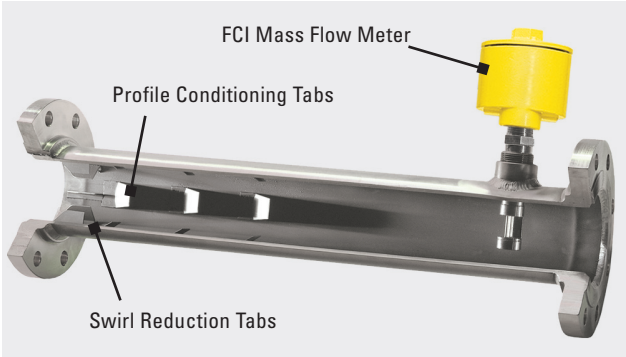

Figure 7. Flow Conditioner with Mass Flow Meter

Art Womack *has over 10 years of experience in the design, manufacture, sales and application of pressure, temperature, level and flow instrumentation. He is presently a manager at Fluid Components International (www.fluidcomponents.com) and is responsible for the application of thermal dispersion switch and meter technology. He is a co-author of US Patent No. 09/487,019 (Process Control Instrument with Multiple Functions). He holds a B.S.E.E. from Rose-Hulman Institute of Technology (Terre Haute, IN).*