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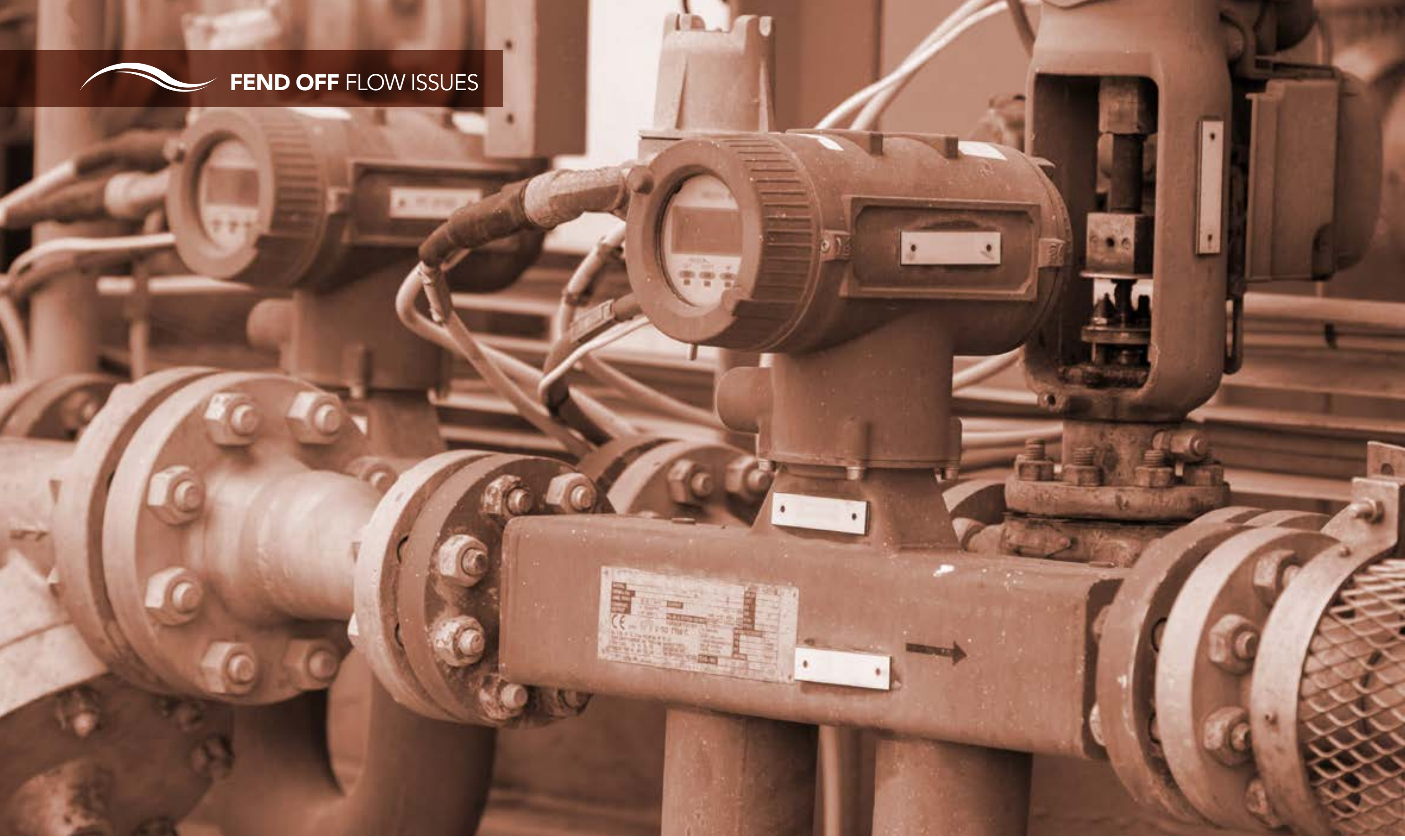

Avoid Splitting Headaches

Ensuring proper control of parallel flow paths demands care

By Andrew Slolely, Contributing Editor

WHEN FLOW goes through parallel paths, both always have identical pressure drops. Flow rates adjust to balance the pressure drops. This often creates situations that don't meet process requirements. In such cases, plants usually install control valves to provide variable pressure drop in one or more parts of the system — to achieve satisfactory flow splits.

Figure 1 shows a typical case of split flow. Path 1 goes through a heat integration exchanger (E1). Path 2 goes through a utility exchanger (E2) to add incremental heat. The control valve on Path 1 (V1) alters the flow to meet the heat integration requirement of the other side of the service. The control valve (V2) on the utility heat adjusts flow to maintain a required downstream temperature.

The flow split between the two paths varies with the pressure drop on exchangers E1 and E2. If they differ in fouling tendencies or cleaning histories, the pressure drop through E2 quite possibly could be low enough that not enough flow would go through E1 even with V1 wide open. This means the heat integration step would remove insufficient heat.

Shifting the control valve position to V3 just may change the problem rather than solve it. With one valve in the V3 position, too much flow may go through E1 even if V3 is fully open. This occurs when E1 is relatively clean.

Depending upon the cleaning history and service requirements, the control pressure drop may need to be in either flow path. Keeping V1 and V2 in their original locations and adding a third valve at V3 provides the needed capability. Many different control configurations are possible. A common one relies on a split-range temperature controller on the E1 outlet to change both V1 and V3. The configuration shown uses a valve position controller. Process characteristics and objectives will determine the best choice among the different options.

Another alternative is to opt for a single three-way valve for controlling the process flow. Figure 2 illustrates two configurations. The first uses a three-way valve in splitting service upstream of the exchangers (V1a). The second puts the three-way valve in mixing service downstream of the exchangers (V1b). The better position will depend upon process characteristics including expected operating temperature, pressure and downstream disposition. The simple system shown combines the two flows. When downstream flows go to

CONTROL OF PARALLEL FLOW PATH

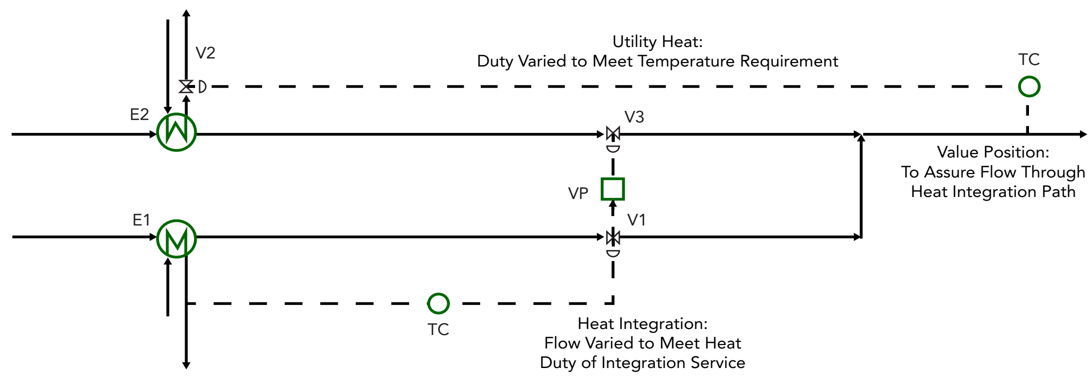

Figure 1. Adding a third valve allows the control pressure drop to be in either path.

different destinations, the splitter configuration usually is used.

Buying and installing one three-way valve typically will cost less than putting in two separate single-flow valves. Nevertheless, plants often avoid three-way valves.

Historically, three-way valves generally were available with linear characteristics. So, systems needing equal-percentage or proportional characteristics weren't seen as good fits for the valves. Today, though, three-way valves come with linear, equal-percentage or proportional characteristics. They even can provide different characteristics for each path.

SYSTEM CURVE

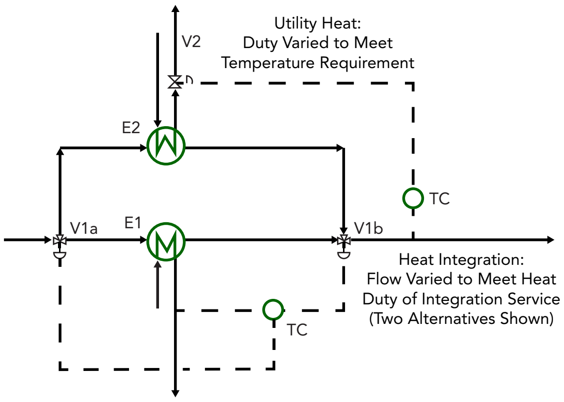

Figure 2. Valve can be located upstream to split streams (V1a), or downstream to mix them (V1b).

However, existing plant layout may work against using a three-way valve. If a single-flow valve already is in place, adding a second one often is cheaper than installing a three-way valve and doing the necessary piping reconfiguration.

In many systems, using a three-way valve creates a new common-mode failure case. Failure of the single three-way valve affects both E1 and E2. While failure of single-flow valves in parallel piping also causes interactions, the effects often are different. In some systems, the extra failure mode is relatively unimportant — for example, when a common failure mode already exists and contingency has been designed into the system. In other cases, addressing the new common-mode failure incurs extra expense to keep the plant safe.

Other requirements such as tight shutoff and special startup, shutdown or minimum flow requirements also might make a three-way-valve application more difficult.

Three-way valves are useful devices that deserve to be considered more often in process plants. However, you always should thoroughly check the possible implications of their use in an application.

ANDREW SLOLEY, Contributing Editor
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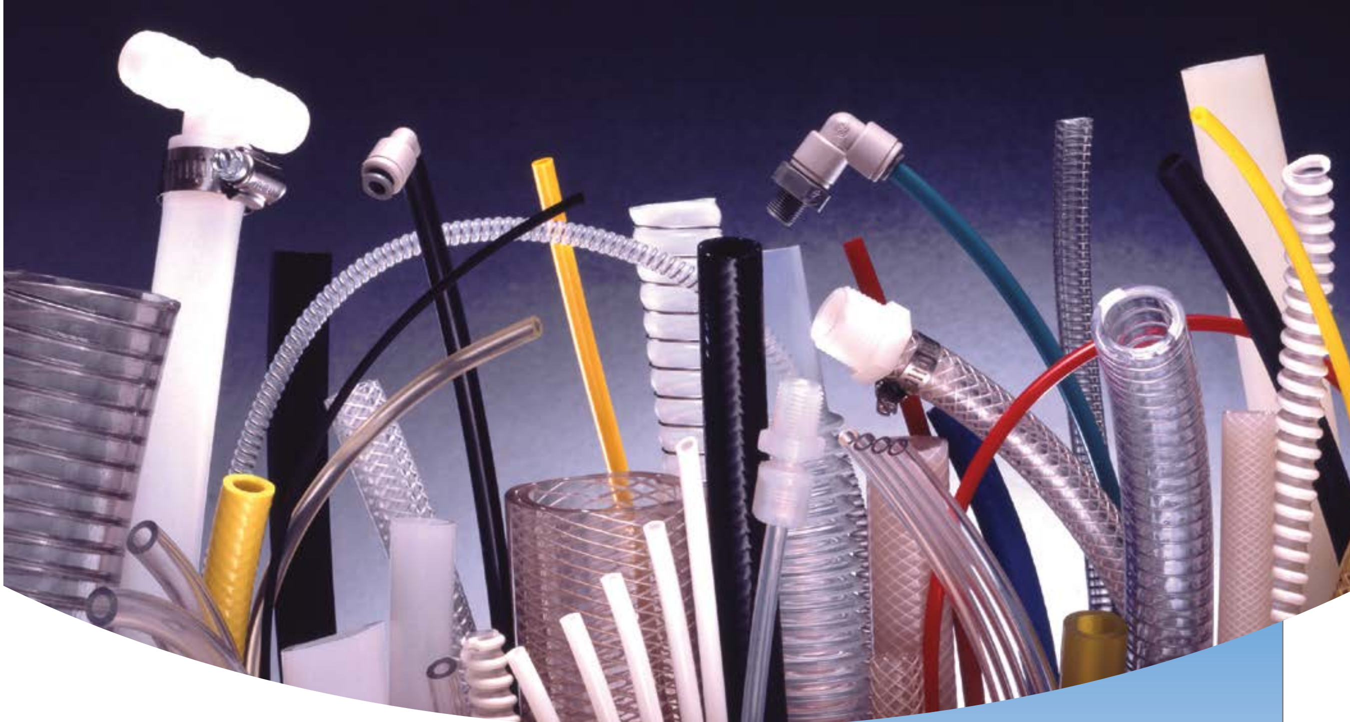

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Consider Positive Displacement Pumps

Such units offer advantages over centrifugal pumps in some services

By Sean McCandless and Richard Meighan, Colfax Fluid Handling

MOST ENGINEERS are more familiar with centrifugal pumps than positive displacement pumps. In many cases, however, positive displacement pumps, particularly rotary variants, can provide the most cost-effective and efficient fluid handling. That's because, unlike centrifugal pumps, which create pressure, positive displacement pumps create flow.

In a centrifugal pump, an impeller rotates to move liquid through the process. The impeller's velocity imparts energy on the fluid. The resulting rise in pressure, or head, is proportional to the velocity of the liquid.

In contrast, a positive displacement pump moves a set volume of liquid. Pressure is created as the liquid is forced through the pump discharge into the system. The pump converts energy into pressure. This is achieved as an increasing volume within the pumping chamber is opened to suction and then is filled, closed, moved to discharge and displaced. The delivered capacity is nearly constant throughout the discharge pressure range. This constant capacity or flow will intersect a system curve at a defined point, allowing a high degree of control (Figure 1).

Some flow variation may occur due to internal slip or pump wear. Slip stems from the fluid's viscosity and the system pressure — with lower viscosity or higher discharge pressure creating more internal slip. Pump wear also results in increased slip. Many factors contribute to wear, including the nature and abrasiveness of the liquid pumped, pressure and age.

It's important to note that a rotary unit will continue to pump if there's a downstream blockage. So, rotary systems require some type of safety pressure-relief valve at or immediately downstream of the pump to protect against over-pressure.

ROTARY PUMPS

Positive displacement pumps come in many different types. Here, we'll focus on rotary pumps. The Hydraulic Institute categorizes rotary units in seven primary segments — vane, piston, flexible member, lobe, gear, circumferential piston

SYSTEM CURVE

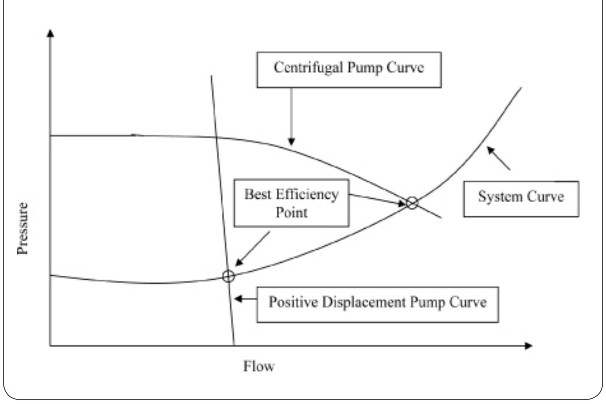


Figure 1. A positive displacement pump provides relatively constant flow.

and screw; this breakdown helps in understanding the various nuances of pump design and operation. (The Hydraulic Institute also provides family trees for kinetic (such as centrifugal), vertical (submersible), sealless centrifugal (canned motor), reciprocating power (horizontal or vertical) and direct acting (horizontal or vertical) pumps.)

Rotary pump types differ in internal components but all operate on similar principles to create flow, as typified by the single- and doubled-ended three-screw pumps shown in Figure 2: liquid enters at suction and moves axially through the pump to discharge; the volume of each pumping chamber determines the amount of liquid delivered.

Table 1 summarizes the method of operation, advantages and limitations of each type. Treat the comments in the table as a rough guide; direct specific questions or comments to vendors being considered.

Figure 3 depicts the pressure-versus-flow capabilities of types of rotary pumps. The ranges and the maximum values shown aren't absolute; custom designs with alternate speeds, clearances or special materials may exceed these values. To learn more, visit the Hydraulic Institute at www.pumps.org.

THREE-SCREW PUMPS

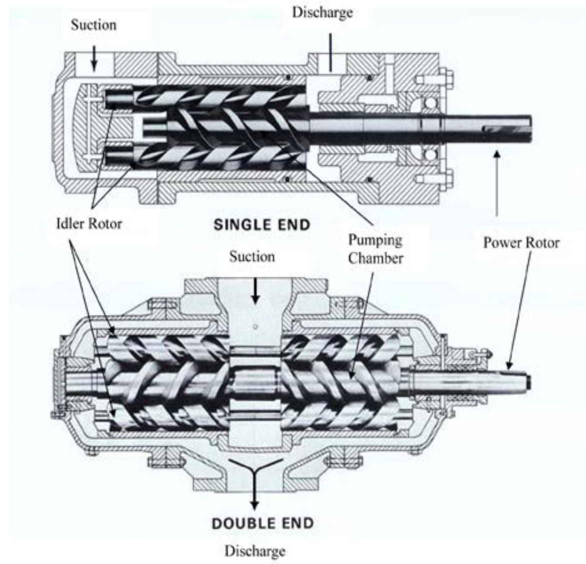


Figure 2. Pumping chamber volume determines the amount of liquid pumped.

PRESSURE VERSUS FLOW CAPABILITIES

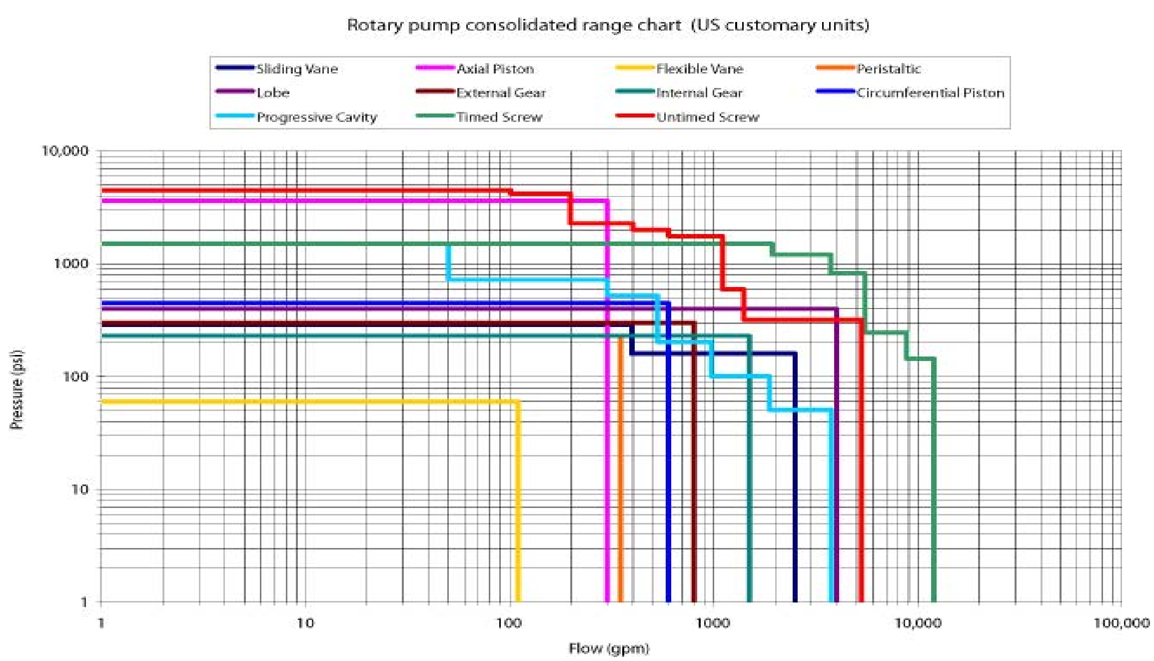


Figure 3. Special designs may exceed the values shown. *Courtesy of Hydraulic Institute, www.pumps.org, Parsippany, N.J.*

PROGRESSING CAVITY PUMP

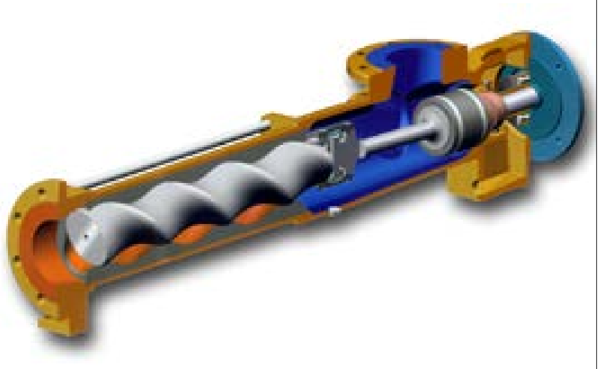


Figure 4. Such a unit is particularly good at handling abrasive fluids.

SCREW PUMPS

These devices are further divided into two segments: single-screw (progressing cavity) and multiple-screw. Multiple-screw pumps, in turn, are classified as timed or untimed. Each of these variants offers distinct advantages and limitations (Table 2).

Let's look at each type in a bit more detail:

Single-screw (progressing cavity). This design most commonly is fitted with a rigid threaded rotor that rotates within an elastomeric stator with internal threads (Figure 4). Although capable of pumping water, it's most effective in handling contaminated and viscous fluids. So, this pump finds wide use in wastewater service and typically is the unit of choice for sludge, as well as abrasive or stringy fluids where the constant flow characteristics of a positive displacement pump are preferred. Sanitary 3A-rated stainless steel versions handle a wide range of food products from meat to dairy, molasses to concentrated juices.

A unique feature of this pump to keep in mind is the option of an auger feeder fit into a hopper-style inlet. This allows the pump to handle up to 45% solids' content. Not many types of pumps can deal with non-fluids such as recycled tires — but a progressing cavity pump can.

The benefits of the progressing cavity pump include:

- suitability for abrasive fluids;
- ability to handle solids and stringy material;
- metering capability;
- availability of sanitary-service designs; and
- low shear.

Timed multiple-screw. The two- or twin-screw pump (Figure 5) typifies this design. Unlike in a single-screw unit, the twin-screw pump's rotor doesn't contact the casing. In fact, there's no metal-to-metal contact between the rotors themselves or the rotors and casing. Rotors are precision machined and supported by bearings synchronized by oil-lubricated timing gears on one end of the rotors. This sophisticated design means the twin-screw pump isn't a low cost option but enables it to handle difficult applications when other designs fail. It truly can be the pump of last resort.

Advantages of the timed twin-screw pump include:

- ability to handle extremely high to water-thin viscosities (such as required for some flushing cycles);
- capability (of some designs) to cope with multiphase feeds (fluid, gas and contaminants);
- ability to provide high flow rates;
- extremely low NPSHR (net positive suction head required), well suiting it for difficult vapor pressure fluid applications;
- high temperature capability;
- extremely low pressure pulse;
- contamination tolerance;
- producible in any metal that can be machined; and
- typically run at full motor speeds even for high flow rates.

This is the design to consider for difficult applications, particularly when two or more of the above factors are important.

Untimed multiple-screw. This technology most often comes with three screws — one power rotor and two

TIMED MULTIPLE-SCREW PUMP

Figure 5. No metal-to-metal contact occurs between the rotors or rotors and casing.

idlers (Figure 6). It also is available in two-, four- and five-rotor versions. All designs operate with the same principle — that is, with the rotor and idler(s) run in a close-fitting housing. The epicycloidal geometry of the rotor set assures a rolling contact; the rotor set runs inside the bore of the casing much like a journal bearing. A film of the liquid being pumped prevents contact of the rotating elements and the bore. Most designs feature axial and radial balancing. Thrust bearings aren't required. When applied and operated properly, such pumps provide a very long service life between maintenance cycles. Units typically are made of iron and steel, and so shouldn't be used in corrosive applications. Also, except for some special designs, this technology only suits contaminant-free fluids.

Unlike the other screw designs, the untimed multiple-screw can accommodate a magnetic coupling for guaranteed leak-free performance. Such pumps handle applications such as machinery lubrication, fluid power hydraulics, fuel injection and compressor seal systems; some special designs are used for high-pressure water-based applications.

Advantages of untimed multiple-screw pumps include:

- very low noise and pulsation;
- high efficiency;
- operation at full motor speed even at high flow rates (allowing application of a smaller pump without gear reducer);
- self priming;
- high reliability (balanced design); and
- ability to be applied on rotating equipment driven by auxiliary shaft at speeds above two-pole motor speeds.

SELECTION GUIDELINES

When evaluating the pump type for your fluid handling system, focus on four key aspects, namely, fluid, discharge, supply and operating objectives. The following general guidelines indicate when a positive displacement pump may be a good choice:

Fluid. Will your pump see liquid viscosities of greater than 20 centistokes, entrained gas or deal with a shear-sensitive liquid? If so, consider a positive displacement pump for its ability to handle high viscosity liquids more efficiently, i.e., with lower annual energy costs, than centrifugal pumps.

UNTIMED MULTIPLE-SCREW PUMP

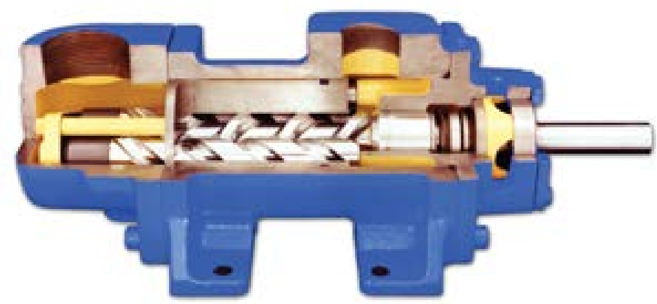


Figure 6. Unlike other pumps, this design can be fitted with a magnetic coupling.

Discharge. Will pressure vary in your system? If so, consider a positive displacement pump for its ability to deliver a nearly constant volume of liquid over the pressure range.

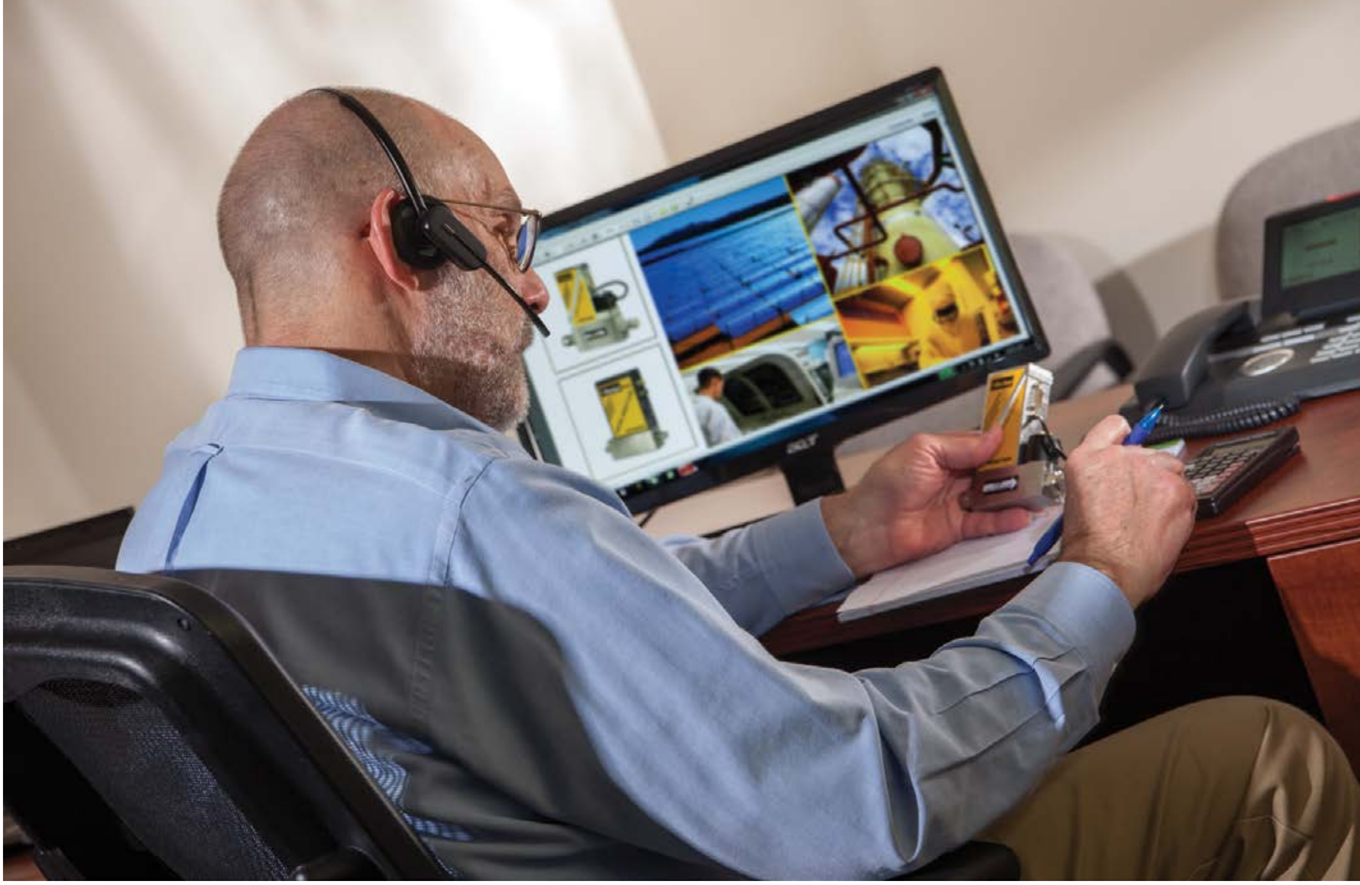
Supply. Will supply conditions vary in your system? If so, consider a positive displacement pump for its versatility in handling a wide range of NPSHA (net positive suction head available), fluid characteristics and ability to adjust speed efficiently.

Operating. Will your flow or pressure demands change occasionally or even frequently? If so, consider a positive displacement pump because of its ability to respond immediately and efficiently to pressure changes and varied speed.

Selecting the right pump type is important — but so too is properly sizing the pump. Many engineers don't appreciate the importance of sizing a pump only to meet the application's requirements. It's common to oversize a pump, for example, in anticipation of future planned expansions. This leads to higher initial and energy costs.

In making a decision on the best pump for the job, take the time to consider suitability, efficiency, reliability, and, perhaps most importantly, the total cost of ownership. A pump's original price may not amount to much compared to the cost of energy and maintenance over its life.

SEAN MCCANDLESS is oil and gas market manager for Colfax Fluid Handling, Monroe, N.C. **RICHARD MEIGHAN** is director, product sales, power generation and industrial markets, for Colfax in Monroe. E-mail them at sean.mccandless@colfaxcorp.com and richard.meighan@colfaxcorp.com.



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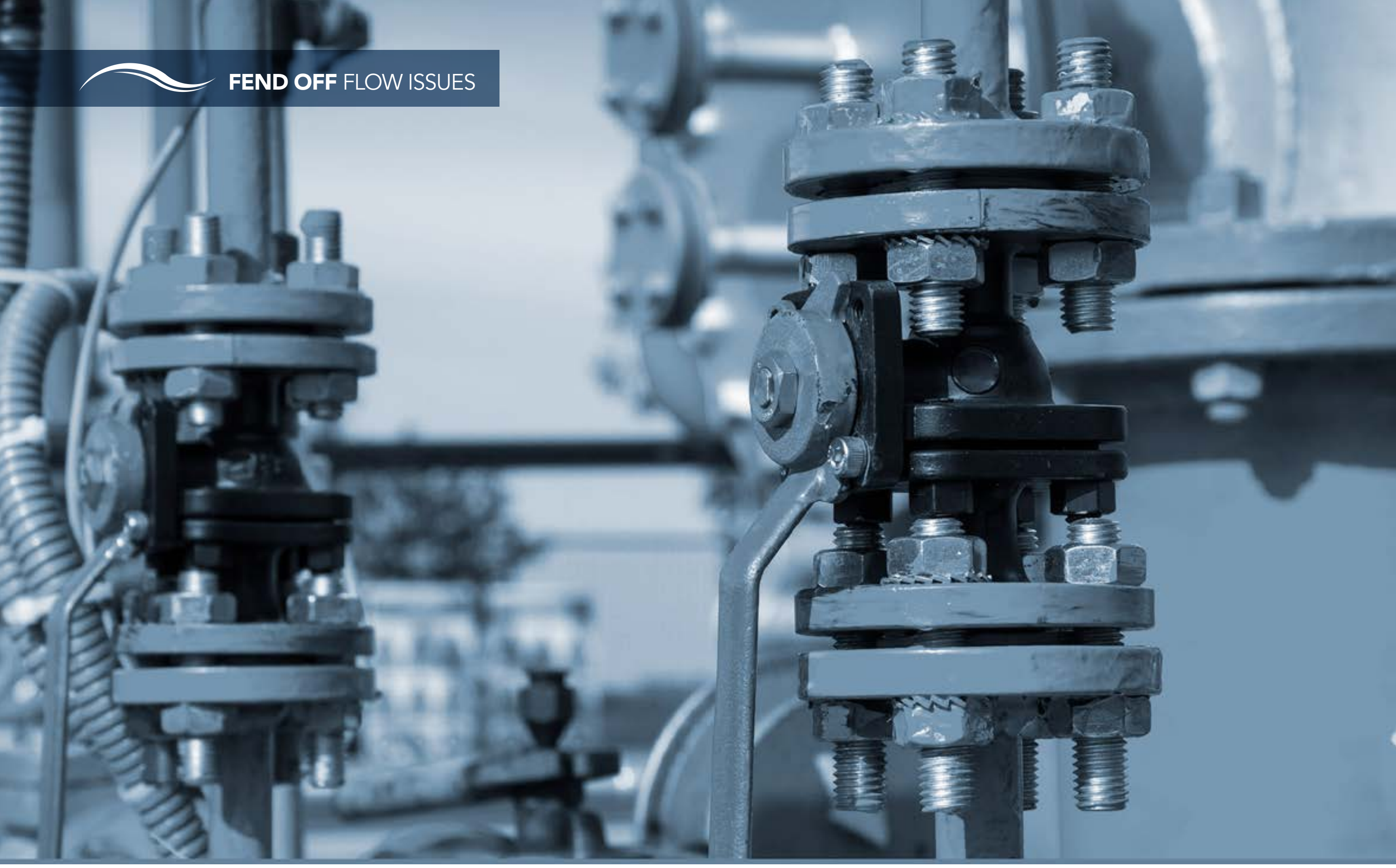

Increase Process Availability

Using Coriolis mass flowmeters provides reliable indication of gas entrainment

By Jack Roushey, KROHNE, Inc.

ENTRAINED GAS can disturb the sensitivity of mass flow measurement of liquids, decreasing accuracy or even stopping measurement completely. New Coriolis mass flowmeter technology has come on the market that ensures both stable and uninterrupted measurements with high gas content. The new meters, including KROHNE's OPTIMASS 6400, offer reliable indication of gas bubbles in the process by using a combination of various measurements to detect a two-phase flow. With values between zero and 100% gas or air content in the line, it maintains continuous mass density measurement and provides measured values at all times. At the same time, it can report the two-phase status and output a preconfigured alarm, in accordance with NAMUR NE 107 requirements.

WHAT IS GAS ENTRAINMENT?

Gas entrainment refers to the presence of gas bubbles in a process. It can occur for many reasons and particularly in terms of sensitive dosing processes, it causes aggravation and headaches for users. Gas bubbles can form, for example, due to degassing; leaks upstream of, or in, a negative pressure area; excessive cavitation and levels falling below the minimum in supply containers; as well as agitators in tanks or long drop distances for media into tanks. However, they can also occur due to status transitions in process control, such as when starting or shutting down the system, or cleaning it.

Other examples include production processes in which gas bubbles are introduced deliberately and the gas flow is measured upstream of the sprayer. This can happen, for example, in the production of shower gels, or processes in which the bubbles are used for control purposes.

The effect of gas entrainment shouldn't be underestimated, because it affects process control measurements and thus results in unreliable product quality. Because of this, NAMUR recommendation NE 107, "Self-monitoring and diagnosis of field devices" for Smart flow measurement processes classifies the presence of entrained gas as an error condition in the highest category, Category 1.

On the other hand, some in the industry caution against making this a bigger problem than necessary, arguing that gas entrainment actually occurs in significantly fewer processes than measurement devices might

Figure 1. Newer Coriolis flow meters can more accurately detect gas entrainment and changing process conditions.

suggest. "Gas bubbles in chemical processes are one of the most frequent reasons that system operators call service employees to test a supposedly faulty device," explains Frank Grunert, global product group manager for Coriolis mass flowmeters at KROHNE. "The user is often astonished to find that the meter is measur tent can be discovered based on the saved density changes."

GAS ENTRAINMENT MEASUREMENT TECHNOLOGY

The reason for these measurement difficulties stems in part from gas measurement technology used. From a measuring technology standpoint, gas entrainment is considered a liquid-gas flow, one of the most frequently observed forms of two-phase flows. Many measured values are required to characterize a two-phase flow, including the percentage volume of the dispersed phase in the continuous phase, the densities of both phases, the morphology (size, shape, distribution) of the dispersed phase that occurs, the viscosity of the continuous phase, the operating pressure and the surface tension of the continuous phase.

Liquid-gas flows demonstrate very different characteristics, and currently there's no measuring principle that can measure all of the parameters. A combination of various measuring principles helps to create a better description of these flows, but the technical effort and expense for such a system would be quite high.

The Coriolis mass principle is very well suited for detecting gas entrainment because it precisely recognizes mass and density changes in the measurement substance. However until recently, gas entrainments posed a great challenge for Coriolis mass flowmeters. The relative movement of the different phases damps the vibration of the measuring tube, and this damping leads to inconsistent vibration amplitudes of the measuring tube. These inconsistent amplitudes then interfere with the electronics' capability to determine the actual resonant frequency of the measuring tube.

In addition, the damping effect caused by the gas content in the liquid in the electro/mechanical driver system of the Coriolis mass flowmeter can be larger than the driver input power. If the vibration of the measuring tube can't be maintained, the result, in an extreme case, is the interruption in measurement.

RELIABLY DETECT PROCESS CHANGES

Fortunately, new technology is now coming on the market to counteract both these effects. For example, KROHNE recently developed the OPTIMASS 6400, which detects and signals gas entrainment reliably and maintains the active measurement in all measuring conditions with gas content from zero to 100% by volume. The device is "gas bubble resistant." The measuring sensor and signal converter were designed to offer complete digital signal processing, from the production of the drive oscillation of the measuring tube to the evaluation of the sensor signals. In this way, it's possible to reliably detect changes in the process

GAS BUBBLE RESISTANT

Figure 2. The OPTIMASS 6400 is not affected by crosstalk.

and to accurately indicate the actual conditions in the production line.

For many years, digital signal processing has been used in Coriolis mass flowmeters, but initially, it was used only in the evaluation of the sensor signals. Until recently, an analog signal circuit was used for drive vibration that amplifies the measured resonant frequency of the measuring tube and returns it to the measuring tube as an impulse signal.

In the case of gas bubbles, the vibration signal is disturbed due to the transients in the damping and the density of the medium. With the analog drive system disturbance recorded and amplified, the impulse signal is disturbed as well. This means a loss in output because the excitation only occurs in the resonance of the measuring tube, which is not efficient, and also leads to a fault in the frequency measurement. Both end up increasing deterioration of the measurement of the tube oscillation and, as a result, the mass flow measurement. They also risk losing control of the driver system, which requires a restart of the meter before measurement can be restored.

The new technology used in the OPTIMASS 6400 has a synthetic driver oscillation and high resolution digital signal processing: the oscillation is produced using a digitally generated and therefore known impulse frequency. The measuring tube oscillation occurs due to this impulse, so the frequency of the measuring tube is known precisely. This connection doesn't change, even with gas bubble disturbance. The control loop remains "clean" and isn't disturbed by interspersed and amplified frequencies. In this way, the OPTIMASS 6400 can accurately measure amplitudes and phases, even in disturbed conditions, and regulate them in the resonance. The device remains in continuous measuring operation, even if there is gas content or air pockets of 0 to 100% by volume in the medium.

Different indicators for gas bubbles are set in the signal converter, which use cross-sensitivities to combine two or more indicators for a reliable diagnosis. According to NAMUR NE 107, the most important requirement is that the results of the diagnosis be reliable, so that the user can take the correct actions.

For many users, a crucial criterion for selecting a measuring device is the accuracy with which it measures the occurrence of gas bubbles. Despite the advances in technology, practice demonstrates that even with these devices, gas bubbles cause changes in the processes. This results in variations of accuracy with mass flow measurement, depending on the process conditions and the system operation of interest to the customer. In addition, gas bubbles can vary widely in size and frequency of occurrence. Likewise, there are changes in temperature, pressure or viscosity that need to be considered. Therefore, users still have to be cautious regarding accuracy of the various available measurements in indicating the occurrence of gas bubbles and changing process conditions.

JACK ROUSHEY is Business Development Manager, Coriolis Mass Flow, for Peabody, Mass.-based KROHNE, Inc. He can be reached at j.roushey@krohne.com

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