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PRODUCT FOCUS

BUTTERFLY VALVE SUITS RANGE OF APPLICATIONS

The Teflon-lined valves are designed to handle harsh, corrosive media

The AS Series PFA Disc/PTFE seat butterfly valves are available from stock in lug and wafer style in sizes 2-12 in., and 14-24 in. on application. The resilient backup liner, live-loaded packing and multiple safety seals reportedly make the AS Series valves ideal for harsh, corrosive media found in chemical processing, pulp and paper, water and waste, marine, semiconductor and food industries. Operating temperatures from -20° F to 355°F, and pressure ratings to 150 psi allow for a broad range of applications.

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Make Success With Centrifugal Blowers a Breeze

Consider a variety of factors to achieve efficient and reliable operation

By Amin Almasi, rotating equipment consultant

Diverse applications rely on blowers to supply gas at relatively low pressure. Process plants usually opt for centrifugal blowers; they use rotating impellers to increase the speed of gas streams. These blowers most often have a single sophisticated three-dimensional impeller — but special blowers sometimes use two or three impellers.

Centrifugal blowers often have variable frequency drives (VFDs) to optimize efficiency as operating conditions change, provide overcurrent protection, reduce power consumption, and facilitate soft startup and shutdown. The most important aspect of VFDs is preventing surge over a wide operating range.

Capacity turndown and delivered head

variation are both important features of a centrifugal blower. Speed variation usually serves as the fundamental means of capacity and head control. In many cases, a system of variable inlet guide vanes (VIGVs) also is installed as another way to regulate the blower operation to give the required operational flexibility. Using both methods, a blower can provide a minimum flow as low as 20–30% of the normal flow rate.

DESIGN AND OPERATION

Overhung designs are popular for centrifugal blowers. In some designs that use a gear unit, the impeller is mounted on the gear unit flange. An overhung design offers many benefits such as simplicity and easy access for servicing the diffuser vane assembly or other parts while the casing is off. For safety reasons, a vent valve allows



CENTRIFUGAL BLOWERS

Figure 1. One blower is operating while the other serves as a standby.

the volute to be purged with inert gas prior to startup.

The impeller usually is three-dimensional semi-open (unshrouded) design. Its vanes typically are machined out of a solid forging. Material options include aluminum alloys, stainless steel and alloy steels — and even titanium alloys for some special applications. The impeller is fixed to the shaft by different methods — a popular one is a cylindrical polygon fit, with its unique torque transmission capability. A key-less option generally is preferred.

Spare parts and redundancy are important for critical components such as lubrication oil pumps, oil filters, oil coolers, etc. Storing individual parts of a component in a warehouse is fine but an entire unit, such as a spare lubrication oil pump, should be

installed as a standby rather than kept in a warehouse. Sometimes, installing a redundant blower is wise (Figure 1). Standby units require regular monitoring to ensure they will work when needed.

Balancing and spin testing are important for impeller assemblies of high-speed blowers. Each element of the rotating assembly, i.e., impeller, shaft, high-speed gear, etc., should be dynamically balanced to close tolerances. The complete rotating assembly once assembled then should undergo dynamic balancing before installation. Finally, during the mechanical test of the complete unit in the shop, vibration probes should verify lack of vibrations due to unbalance.

For many high-speed blowers (say, above 9,000 rpm), balancing the whole high-speed rotor assembly to ISO 1940 Grade G1

is desirable. However, in some cases, G1 isn't possible and, for many other cases, assembly balancing to ISO 1940 Grade G2.5 will suffice. Blower impellers usually undergo a spin test in a vacuum chamber at 1.2 times the nominal speed (or 1.15 times the "maximum continuous speed") together with dimensional checks before and after the test.

Shop performance tests have been specified for many process blowers, with ASME PTC-10 used for many critical units. However, for low-pressure blowers, vendors often propose testing with compressed air in an open loop configuration to reduce the cost of the performance testing. For some of these blowers, such a performance test can't accord with ASME PTC-10 because air can't provide aerodynamic similitude. For example, if a large process gas blower must comply with the ASME PTC-10 performance test, using air as the test medium would require the blower to reach 124% of design speed, which may be impossible.

VIBRATION AND RELIABILITY

Radial vibration sensors and monitoring commonly are specified for blowers. X-Y vibration measurement probes for each bearing and a keyphasor transducer for each shaft usually are provided. Sometimes axial probes aren't specified for low-pressure blowers. This is a major error. While some engineers think axial sensors only are useful for high-pressure applications, this isn't true. Many mechanical issues and dam-

aging mechanisms, such as misalignment, bent shafts, etc., do create axial vibration. In addition, axial loads and axial vibration (movements) can be affected by machinery process load changes, variation in operating conditions, surge, other operational issues, etc. Axial displacement probes can identify all these very effectively. Moreover, axial vibration measurement will help avoid or predict issues with the thrust (axial) bearing/collar (or similar device), which often is a vulnerable part in such a machine and the cause of many difficulties and failures. High axial vibration also can result in seal problems. Protecting both the thrust bearing and seal requires axial displacement probes. This is particularly true for any blower above 250 kW or in a critical process service.

In some blower applications, uncertainties in suction/discharge conditions and operating situations exist; in those services, axial vibration movement/probes are a good tool to help mitigate these uncertainties and achieve long-term safety and reliability.

SEALS

In a process blower, a shaft seal usually is installed to separate the process side from the lubrication oil system. Dry gas seals generally aren't employed because pressures aren't high enough. Instead, carbon-ring seals and labyrinth seals commonly are specified and supplied for low-pressure blower applications. The simplest choice

is a buffered labyrinth seal; it often is used for air or non-process blower applications. A common option for process blowers is a buffered carbon-ring seal (most often with nitrogen as the buffer gas). Depending on application, a backup seal (usually an additional labyrinth seal) may be provided.

A combined carbon-ring and labyrinth seal is a good choice for blowers. It consists of a dual carbon-ring seal for normal use together with backup labyrinth seals; this limits the consumption of seal gas (usually nitrogen) in case of damaged or worn-out carbon rings. This novel technology combines lowest possible seal-gas consumption with good reliability due to the backup characteristic. The seal gas is injected into an intermediate chamber between the two carbon rings and flows both ways from the injection point. A slight process gas stream leaks from impeller tip through the rear impeller labyrinth into the first chamber behind the impeller where it mixes with one portion of the injected seal gas. This chamber is vented to the blower suction, and as such, relieves the area behind the impeller to near suction pressure. Due to the very small clearance between the carbon-ring seal and the shaft sleeve, the amount of seal gas is about 5 to 6 times smaller than that with a conventional labyrinth seal.

RETURN GAS BLOWERS

One well-known application for blowers is to return boil-off gas, generated gas or

vapor to large storage facilities while they are being unloaded. The gas or vapor fills the void being created by the leaving liquid, thereby preventing tank collapse or the introduction of air/oxygen into the system. These services require a customized blower that can handle a wide variety of operating conditions at relatively low pressure ratios (say, pressure ratios around or below 2). As rough indication, typical volumetric flow rates could be 1,000–40,000 m³/h, and pressure deltas around 0.5–1.5 bar. Many designs use gear units. However, some modern blowers feature high-speed motors that eliminate the need for a gearbox and maximize efficiency and reliability.

ANTI-SURGE VALVES

The surge phenomenon in blowers (and compressors) can be understood as a complete breakdown and reversal of the flow through the machinery. Every centrifugal blower (or compressor) has its own operating characteristic map and surge limits.

A centrifugal blower should have a fully engineered anti-surge system to prevent the machine from going into surge at startup, shutdown and during low-flow operation. This, as a minimum, should comprise a blower discharge-to-suction bypass loop incorporating an anti-surge-valve actuated by a suitable control system. Review anti-surge system details with great care.

Anti-surge-valve sizing and system design

should follow modern engineering practices and well-established rules. For example, some commonly used guidelines suggest keeping the anti-surge-valve flow coefficient, C_v , within the range of around 1.8–2 times the required C_v based on the blower surge flow on the highest blower speed curve (on the blower map). For some specific cases, though, the anti-surge-valve C_v might be as low as 1.75 times the required C_v ; don't go lower than this. Also, ensure the anti-surge piping line is as close as possible to the blower, and minimize pressure loss in the anti-surge loop.

Having an appropriate C_v and meeting valve-size and stroking-speed requirements is only the first part of anti-surge-valve selection. Ensuring the anti-surge valve can perform well in closed-loop control also is

important. After all, eliminating the potential for surge and damaging vibration in the blower system normally is a bigger concern. Properly addressing this requires attention to other parameters — noise, trim details, actuation system specifics, and many more.

Coupling the latest technologies in anti-surge-valve and actuator designs with smart positioner technology and good accessory selection usually is key to achieving optimal performance from an anti-surge system.

AN EXAMPLE

Let's consider the selection of a centrifugal blower for a critical process service with a maximum flow rate of around 28,000 m³/h. Five operating cases with different flow rates and pressures have been identified

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for this blower. As an indication, the minimum suction pressure is 1.02 bara and the maximum discharge pressure is 1.51 bara. Maximum pressure delta is 0.49 bar. After a thorough optimization, the selected blower speed is 9,100 rpm and the motor power is 570 kW. This is a high-speed blower using a 3,000-rpm induction electric motor and a gear unit with gear ratio slightly more than 3. It has a sophisticated three-dimensional semi-open impeller with a diameter exceeding 500 mm and a tip speed of around 225 m/s. The trip speed is set at 9,900 rpm. This blower has an estimated overall efficiency of 73%. For operational flexibility, it is equipped with pneumatically actuated VIGVs as well as a VFD that can adjust speed from 50–103% of nominal. Using both VIGVs and VFD, the minimum flow achievable is around 8,500 m³/h.

The blower has titling-pad radial bearings and a tapered-end axial bearing of around 100-mm diameter. The shaft seal consists of a nitrogen-buffered carbon-ring seal with a backup labyrinth seal. A barrel-type casing is used; the sizes of the suction nozzle and discharge nozzle are 24 in. and 20 in., respectively.

The main lubrication oil pump is a 3,000-rpm screw pump that is coupled to the gear unit. In addition, an auxiliary lubrication oil pump — an electric-motor-driven pump (again, a 3,000-rpm direct-driven unit) — is provided; it also is used for startup. Each pump will supply oil at 9.9 m³/h with 6 barg discharge pressure; each pump has a power rating of around 5 kW (around 1% of the main electric-motor-driver power rating).

The volume of the lubrication-oil stainless-steel tank is around 850 liters (giving around 5-min. oil-retention time). Two aluminum-alloy air-coolers (one operating and one standby) are provided for the lubrication oil system; duplex oil filters are fabricated from stainless steel. The specified lubrication oil is ISO VG 46.

The anti-surge valve for this blower is 18-in., which was sized using an anti-surge-valve C_v of 1.78 times the required C_v based on the blower surge flow on the highest blower speed curve (on the blower map). ■

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Prevent Paired-Pump Problems

Operating centrifugal pumps in series demands care

By Andrew Sloley, Contributing Editor

The centrifugal booster pump was vibrating and running hot. The pump took liquid from two sources and pumped it to a third unit. Figure 1 shows the original pump installation — as well as equipment added later and a better option, as we'll discuss.

The original plant concept called for initially installing two matching modular units, Unit 1 and Unit 2, with a third identical unit, Unit 3, to be put in later. Each unit would handle the same specific product, with the streams then combined and sent to a downstream unit, Unit 100, for further processing. Because the product streams didn't have sufficient pressure to get into Unit 100, the design included a common booster pump, P100, with a fixed-speed electric driver to provide the necessary head.

At startup, Unit 1, Unit 2 and Unit 100 were available. However, the booster pump P100 experienced vibration and other problems.

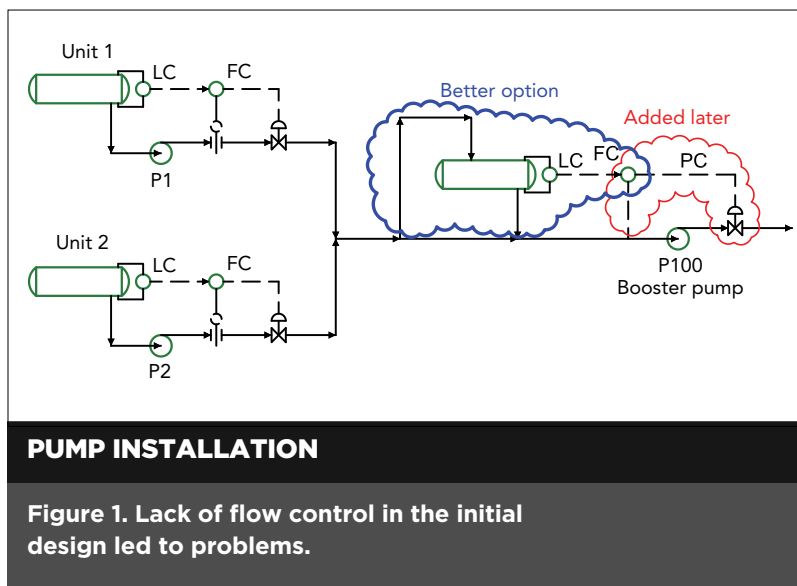
Without a control device, a centrifugal pump will operate along its head curve. In the original configuration shown in Figure 1, the upstream level controllers define the supply rate to P100 while the differential pressure between the suction and discharge conditions sets its discharge rate. Unless there's an amazing coincidence, these rates never will match.

How the pump operates in such a situation depends upon the relation between the supply and discharge rates. In this case, P100 was over-sized for both the startup and even the future expanded operation.

The discharge rate always exceeded the supply rate. However, the discharge rate must equal the supply rate over time. So, the pump cavitates; cavitation drops the pump capacity. When enough cavitation occurs, the pump discharge rate equals the pump supply rate. For this plant, the cavitation was severe. Extreme vibration resulted.

Many plants run centrifugal pumps in series and have them work well. The simplest way to do this is to have one pump feed a second pump and have a flow control valve downstream of the second pump. Putting pumps in series may lead to mechanical and other problems but the linked pump pair avoids incurring control difficulties.

This particular plant has two small pumps whose output streams combine and then feed a large booster pump. This adds challenges to making the system work.



Possible solutions include:

- providing individual booster pumps for both Unit 1 and Unit 2
- installing a feed surge drum to P100 suction (shown as the “better option” in Figure 1); or
- adding a fast loop with backpressure control on P100 suction.

The plant opted for the fast loop with the suction pressure controller. This forces the pump capacity low enough that the suction pressure never drops below the vapor pressure, thus avoiding cavitation. Nevertheless, the solution wasn’t ideal. The control valve forced the pump

back along its performance curve. The new flow rate still left vibration rates too high. Now the vibration came from inlet and outlet recirculation instead of cavitation. (For a discussion of inlet recirculation, see <http://goo.gl/94Ndeg>.)

The cheapest way to achieve a long-term solution is to install a suction drum for the booster pump. The main disadvantages of this option include the plot space required and an increased liquid inventory.

The other option, adding individual booster pumps to both Unit 1 and Unit 2

and eventually Unit 3, costs more. However, it offers the advantages of smaller plot space requirements and lower liquid inventory.

Having two centrifugal pumps in series with no flow control in this service is simply a mistake. There is no excuse for the original configuration. Such an error

should prompt a reassessment of work processes. How did this configuration get past hazard-assessment, operability and other reviews? What changes in workflow and responsibilities are necessary to prevent such a blunder in the future? Everyone makes mistakes. Effective organizations learn from their mistakes and improve. ■

PRODUCT FOCUS

PROCESS ANALYTICS WITH CLAMP-ON ULTRASONIC TECHNOLOGY

Analyzer measures concentration, density and mass flow rates in real-time

The ultrasonic clamp-on process analyzer PIOX S is used to measure concentration, density and mass flow rates of a liquid in real-time by determining the acoustic velocity of the medium.

PIOX S transfers the practical advantages of clamp-on ultrasonic technology to process analytical applications. Because the transducers are mounted on the — safe — outside of the pipe, they are not subject to any wear and tear by the medium flowing inside. Moreover, as there is no need to open the pipe for installation, mounting and initial operation can usually be done during ongoing operation. Non-invasive process analytics are suitable for almost all pipe sizes and materials — whether it's steel, plastic, glass or special materials with inline or outer coatings, in a nominal size range of ¼ in. to 20 ft, for temperatures up to 750°F as well as for hazardous areas. The transducers and transmitters also are available in FM-certified designs.

The analyzer is said to be ideal for materials and processes that demand the highest levels of safety and reliability, e.g. in the case of corrosive media like strong acids or alkalis or even toxic compounds.



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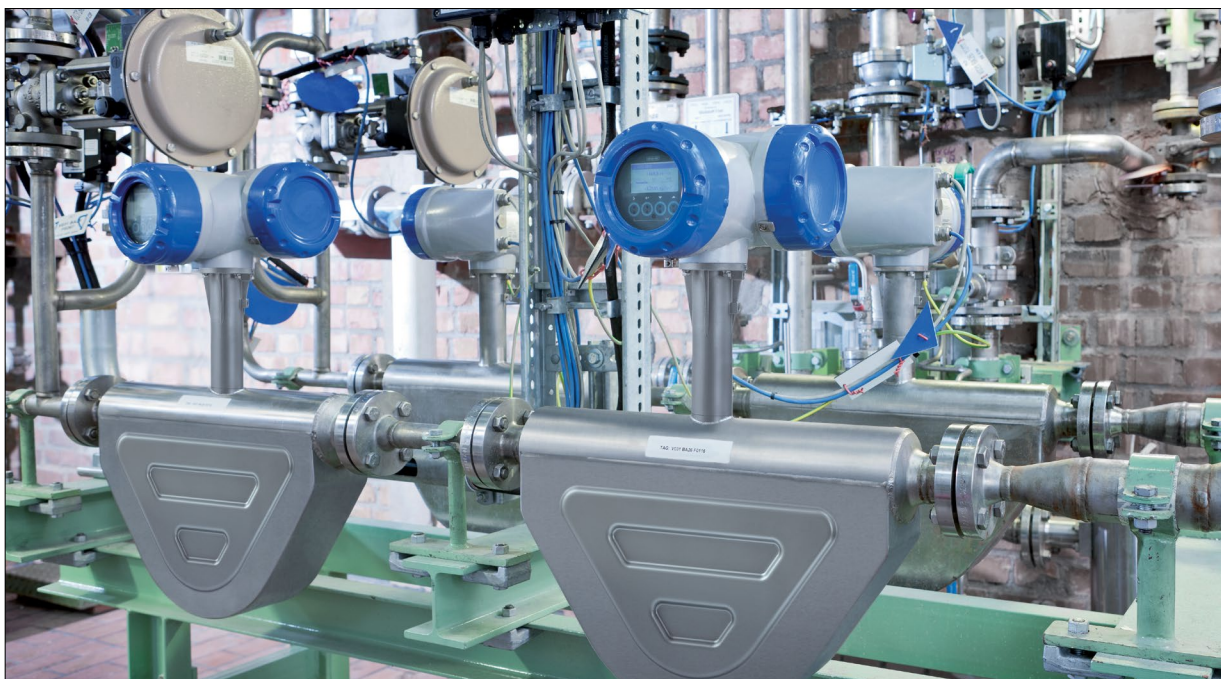
Coriolis mass flow meters can provide reliable indication of gas entrainment

By Steffen Baecker, Krohne Business Development - Flow

Entrained gas can disturb the sensitivity of mass flow measurement of liquids, decreasing accuracy or even stopping measurement completely. New Coriolis mass flow meter technology has come on the market that ensures both stable and uninterrupted measurements with high gas content. The new meters 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 0 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.

THE CHALLENGE OF 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.



CORIOLIS MASS FLOWMETER

Figure 1. Advances in technology allow some flow meters to provide accurate measurement even when gas bubbles are present.

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 should not to 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 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 flow meters at Krohne. “The user is often astonished to find that the meter is measuring according to specifications and the unexpected gas content 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 is 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 flow meters. 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 flow meter can be larger than the driver input power. If the vibration of the measuring tube cannot be maintained, the result, in an extreme case, is the interruption in measurement.

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 0 to 100% by volume (Figure 1). 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 is possible to reliably detect changes in the process and to accurately indicate the actual conditions in the production line.

For many years, digital signal processing has been used in Coriolis mass flow meters, 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 is not disturbed by interspersed and amplified frequencies. In this way, the flowmeter can accurately measure amplitudes and phases, even in disturbed conditions, and regulate them in the reso-

nance. 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. ■

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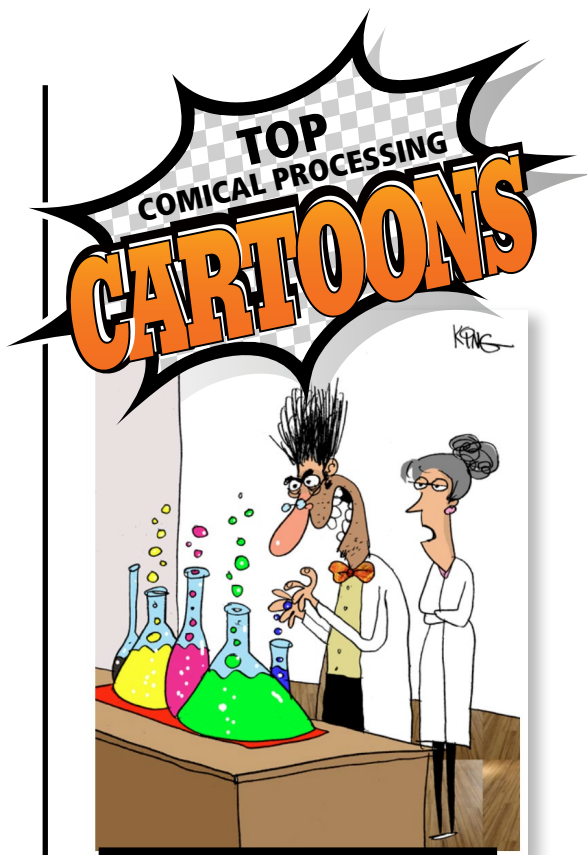
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