Increase Process Availability By Using Coriolis Mass Flowmeters

Reliable indication of gas entrainment

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 one hundred percent 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.

Gas entrainment – what is it and why does it matter?

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 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 flowmeters 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 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 cannot be maintained, the result, in an extreme case, is the interruption in measurement.

New technology reliably detects and signals gas entrainment

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 one hundred percent 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 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 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 does not change, even with gas bubble disturbance. The control loop remains “clean” and is not 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 percent 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.