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fundamentals of automation

MARCH 2022

Flow & Level

Comparing Ultrasonic and Radar Level Measurement

CASE STUDY: Texas BASF Plant Selects Coriolis Flowmeters

How to Improve Boiler Efficiency

CASE STUDY: How Hydrogen Admixture Impacts the Natural Gas Grid


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Introduction

Flow-measurement instruments ensure the accurate amount and movement of fluids in many applications. Levels in liquids, pastes, bulk solids, or liquefied gases are often measured in tanks, silos, or movable containers. For continuous, interface, and density measurement as well as for point level detection, a broad range of measuring instruments is available.

This edition of *InTech FOCUS* explains the differences between ultrasonic and radar measurement technologies to ensure accurate levels are maintained. You'll also read about how Coriolis flowmeter technology improved the integrity of an SIS at a chemical plant in Texas, which flowmeter technology can help improve boiler efficiency, and how adding hydrogen affects the natural gas grid. Find out more in this edition of *InTech FOCUS* highlighting flow and level measurement.

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Comparing Ultrasonic and Radar Level Measurement

The differences and benefits of ultrasonic and radar technologies and for which applications ultrasonic should be considered.

By Scott Peterson, Endress+Hauser

Radar technology is increasingly viewed as the best method of level measurement, but this isn't necessarily true for every application. Radar sensors have made great advances in performance, accuracy, and cost, but they are not a one-size-fits-all solution and should not be treated like one.

Though radar is versatile, there are some applications where ultrasonic level technology is a better fit. Approaching level measurement with a fit-for-purpose mindset instead of a blanket approach is important for safety, performance, and overall product quality. This article explains the differences and benefits of ultrasonic and radar technologies and for which applications ultrasonic should be considered.

Ultrasonic level sensors use the time of flight (ToF) principle to measure level. The ultrasonic transducer generates a mechanical sound pulse, which is directed through air to the process. When this pulse encounters the process surface, it reflects the sound pulse back to the transducer. The transmitter is essentially a high-tech timer measuring the time it takes the pulse to travel to the process and back, which is directly proportional to the distance from the gauge to the process surface.

Ultrasonic versus radar level measurement

Radar level measurement operates based on the same ToF principle as ultrasonic. However, radar uses high frequency microwaves emitted from an antenna. Rather than reflecting based on a change in density as sound waves do, microwaves reflect based on a change in impedance caused by the change from a low dielectric medium (air) and a higher dielectric constant of the process medium.

Since microwaves are electromagnetic and do not require air as a transmission medium, radar is well suited for use in a vacuum or when other gases are present in the empty space. Radar is a safe solution even under extreme process conditions such as pressure, temperature, and vapors.

The ultrasonic method is a proven and cost-effective solution for level measurement in liquids and bulk solids. It is characterized by easy planning and assembly, fast and safe commissioning, a long service life, and reduced maintenance costs. Since ultrasonic does not rely on dielectric constant for reflection, it is well suited in use where the process media has low (less than 1.5) dielectric constant, with the exception of hydrocarbons. It is also well suited for open channel flow measurement and in use with weirs or flumes.

Ultrasonic sensor applications

The main limiting factor for radar is the dielectric constant. Materials with low dielectric constants may not provide enough change in impedance to cause a reflection. This results in the microwave energy passing through it and reflecting off the vessel bottom. Some materials with dielectric constants too low for free space radar are dry saw dust, wood chips, white cement, and many types of plastic pellets. For these applications, ultrasonic transmitters can provide measurement where the radar transmitter would not.

Some users moved away from ultrasonic sensors because of previous challenges caused by dust buildup or condensation on the transducer's faceplate. However, an ultrasonic sensor equipped with automatic self-cleaning eliminates failures caused by dust buildup (figure 1).

Ultrasonic sensors can help overcome the challenges end users might experience in tight spaces. They are ideal for installation in tight places due to the relatively small size of the sensor and the ability to mount a sensor directly to a ceiling. An ultrasonic sensor also can be helpful in cases of flooding. When used with a flooding protection tube, the sensor can ensure a high measurement is indicated even if it is under water.

In outdoor installations where temperatures can drop below freezing, ultrasonic sensors with an integral heater can prevent ice formation on the device. This ensures year-round reliable measurement. Icing can cause issues with radar, as the ice has a high dielectric constant that may

Figure 1. an ultrasonic sensor equipped with automatic self-cleaning eliminates failures caused by dust buildup. Shown are the Endress+Hauser Prosonic FMU42 (left) and Prosonic FDU91 (right).

attenuate the radar signal at or near the source. If this occurs, there will not be sufficient radar signal reaching the product surface to provide a level measurement.

Final thoughts

Endress+Hauser offers a broad range of devices for ultrasonic level measurement. The Endress+Hauser Prosonic product line features 12 ultrasonic ToF sensors and two powerful transmitters. All are unaffected by dielectric constant, density, and humidity. They also are unaffected by dust or condensation buildup. The Prosonic FMU90 ultrasonic transmitter coupled with a FDU9X transducer is a recommended choice for many of these applications. The FMU90 offers additional features like totalization, data logging, differential measurement, pump control, and open channel flow tables. The FMU90 is also available in a two-channel model to reduce overall hardware costs.

To learn more about ultrasonic, radar, and other level measurement technologies, visit www.eh.digital/level_us.

ABOUT THE AUTHOR

Scott Peterson is the national product manager for level products at Endress+Hauser USA. He is responsible for the strategic direction of the level business unit including life cycle management, technology, and application identification, as well as marketing and business development for the level products. Peterson has a BS degree in electrical engineering and has spent more than 32 years in process instrumentation and control with industry-leading companies.

Additional Resources

"Global Water Scarcity Driving Market for Ultrasonic Level Measurement Devices"

"ARC research reveals advances in radar level measurement devices"

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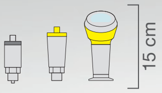
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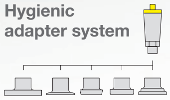

How Hydrogen Admixture Impacts the Natural Gas Grid

Exploring hydrogen admixture from renewable energies into the natural gas grid and the associated suitability of ultrasonic gas meters and power-to-gas technology.

By Duane Harris and Daniel Heinig, SICK

In addition to requirements for a secure, reliable, and affordable power supply, the idea of sustainability within the context of the energy revolution is coming into focus. Renewable energy sources such as wind, water, or solar have an important role to play in this energy mix.

Since the electricity generated from these upcoming—but highly fluctuating—energy sources cannot be transported or consumed in a way that allows for grid compensation, it must be stored. One possibility is to store the energy as gas in the existing natural gas network. For years, there have been developments toward converting electrical energy into storable gases such as hydro-

gen (H2) or synthetic natural gas. The process of converting electricity into gas by electrolysis is known as power-to-gas (PtG or P2G). The hydrogen produced can be fed into the existing natural gas network, stored there, transported, and consumed as required.

In numerous countries of the European Union, research projects have been running since about 2010 looking at the question of how much hydrogen the existing natural gas network is able to absorb without the gas consumption points being negatively affected. In industry, different limit values for the admixture of H2 with natural gas are currently mentioned. Values typically range from 5 to 25 percent by volume. However, the proportion will increase steadily over the coming years. How quickly this happens will depend on the speed of investment and the progress made with developing power-to-gas technologies.

How the admixture of hydrogen into natural gas affects installed infrastructure is of increasing concern. In December 2014, the Physikalisch Technische Bundesanstalt (PTB) issued the Technical Guideline TR G 191, which regulates "feeding hydrogen into the natural gas network" for "measuring instruments for gas."

The guideline declares that the use of gas measurement devices "of any technologies" shall be safe, provided the hydrogen content of the natural gas is less than 5 percent by volume. The use of meters is permitted for a proportion between 5 and 10 percent by volume of hydrogen, provided the manufacturer explicitly permits this. For the use of meters with natural gas containing greater than 10 percent hydrogen by volume, a manufacturer's declaration as well as a PTB declaration of clearance must be submitted in addition to the manufacturer's declaration.

FLOWSIC600 and FLOWSIC600-XT gas meters installed today can be used in applications with up to 10 percent hydrogen by volume in natural gas. This is possible within the calibration error limits and without the need for a new metrological test. SICK has published a corresponding manufacturer's declaration in accordance with TR G 19.

Since applications with more than 10 percent hydrogen by volume in natural gas require an evaluation of the respective application, SICK will, after further investigations, prepare a corresponding manufacturer's declaration and arrange for the PTB safety certificates in accordance with TR G 19.

How the admixture of hydrogen affects measuring capability

The addition of hydrogen influences the characteristic curve behavior and the measuring uncertainty of devices. A measuring capability is not the same as an unchanged measurement accuracy.

The latest test results of an ultrasonic gas meter calibrated with natural gas show the relative error (measurement deviation) on the measurement result (figures 1 and 2) caused by a hydrogen admixture of 10 percent and 25 percent by volume, respectively.

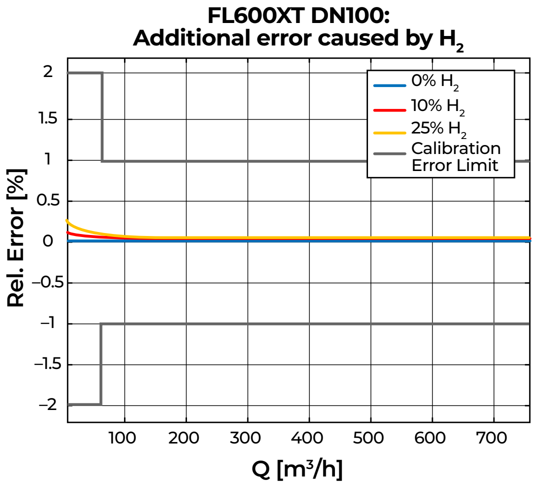

Figure 1. Influence of the H2 content on the measurement error of a DN100 FLOWSIC600-XT after application of the linearization correction, based on pure natural gas data.

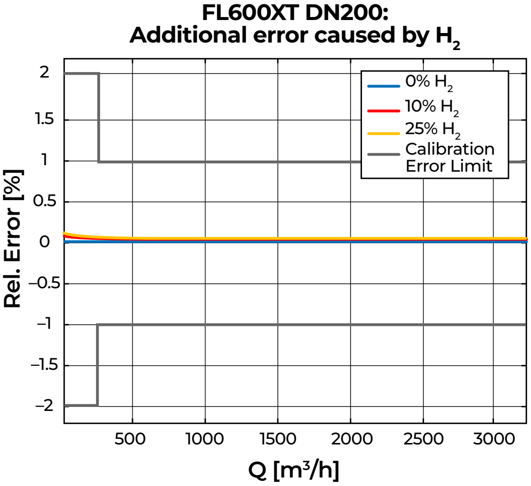

Figure 2. Influence of the H2 content on the measurement error of a DN200 FLOWSIC600-XT after application of the linearization correction, based on pure natural gas data.

The relative error is about 0.1 percent with a proportion of 10 percent hydrogen by volume in the natural gas in the lower flow rate range (Qmin). This error lies far within the transport error limits for natural gas measurements subject to calibration. Similar data was published in a technical report by gwf-Gas in May 2013. A FLOWSIC600 DN80 was used for the investigations.

The report concludes, "Up to 10 percent H2 content by volume, no influence on the ultrasonic gas meter can be detected if the hydrogen is well mixed with the natural gas." SICK ultrasonic gas meters can measure natural gas containing hydrogen. A recalibration is not necessary if up to 10 percent by volume of hydrogen is fed in.

In addition, an admixture of 25 percent by volume of hydrogen has already been evaluated and, with the technology currently installed in the field (sensors and electronics), especially in the lower flow range, this has a slightly higher influence on the measurement accuracy, which is about 0.2 percent.

By correcting for the gas composition in the gas meter, the indicated influence on natural gas calibrated devices can be reduced. SICK is working on appropriate measures so the owner/operator can easily carry out the correction.

How hydrogen admixture affects material compatibility

The Federal Institute for Materials Research and Testing (BAM), in its report titled "Resilience assessments of metallic container materials and polymeric sealing/coating and lining materials" of January 2015, examined the material resilience of certain materials for use with natural gas containing hydrogen.

This shows that gas flowmeters made of the usual material alloys (steels) and other parts in contact with the medium, such as ultrasonic probes and sealing rings, are resistant to natural gas containing hydrogen.

How hydrogen admixture affects explosion protection

Hydrogen has a different specific ignition capability from that of natural gas. Considering purely hydrogen flowrate measurements, the applicable explosion group under explosion protection regulations is IIC. This defines higher requirements for the equipment regarding ignition gap dimensions and energy inputs than for natural gas. Explosion group IIA is sufficient for a natural gas measurement.

In September 2016, the Federal Institute for Materials Research and Testing (BAM) published its report titled "Safety properties of natural gas/hydrogen mixtures," looking into the effects of admixing hydrogen with natural gas on explosion behavior and requirements for the explosion group.

This report shows the explosion pressure changes only slightly up to an H2 proportion of 25 percent by volume. Likewise, a 10 percent by volume admixture of hydrogen has no significant influence on the standard gap width for the gas group IIA (figure 3). The results lead to the conclusion that a 25 percent admixture of hydrogen by volume likely does not inadmissibly reduce the standard gap width for the gas group IIA.

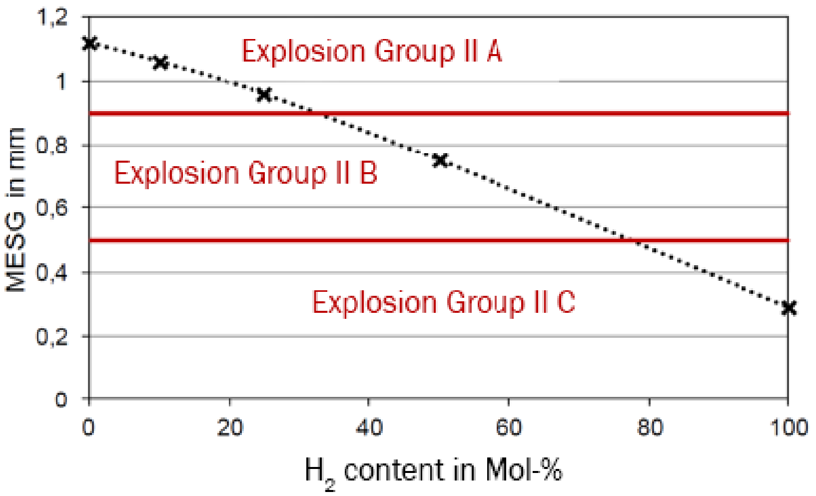

Figure 3. Measured standard gap widths of mixtures of model natural gas and hydrogen (measured values connected with trend line).

According to the German Gas and Water Association (DVGW), work is underway on further developing the rules for admixing hydrogen into the natural gas network. Currently, a 10 percent admixture of H2 by volume is possible with the current rules under consideration of specific applications or restrictions. The new regulation is intended to increase the admixture to 20 percent by volume. According to the current state of knowledge, this proportion is estimated to be technically feasible.

Based on current publications, the conclusion can be drawn for installed SICK ultrasonic gas meters FLOWSIC600 and FLOWSIC600-XT that for a natural gas mix with 10 percent proportion of hydrogen by volume, there will be no need to adapt the electronics or ultrasonic sensors from the perspective of explosion protection.

Looking ahead

The Scientific Service of the German Bundestag, in its June 2019 report, "Limit values for hydrogen (H2) in the natural gas infrastructure," has already reached the conclusion that "from the chemical and technical point of view of some operators…infeed into the natural gas infrastructure has not yet been conclusively clarified in all individual aspects, and there is still a need for development activities and regulatory adjustments. Opinions also depend on the hydrogen process chain (e.g., electrolysis processes or methanization) on end users and on the economic environment."

Gas flow meters of the SICK FLOWSIC600 and FLOWSIC600-XT families, due to their ultrasonic technology, are already suitable for measuring natural gases containing proportions of hydrogen up to 10 percent by volume within the scope transport according to the laws of calibration. The reliability and quality of the measurement results are not affected by changes in density, flow velocity, or speed of sound.

SICK will continue to investigate the measuring capability of ultrasonic gas meters for hydrogen-containing natural gas, especially with proportions of 25 percent by volume (and above), and if necessary, will adapt the measuring devices to meet the market requirements for precise gas flow rate measurement that are capable of meeting calibration requirements.

All images courtesy of SICK.

ABOUT THE AUTHORS

Duane Harris is a market product manager at SICK Inc. for the process automation industry. With more than 30 years of experience in the industry, he brings experience as a manager of gas measurement at Panhandle Energy for 17 years to his sales and product marketing roles.

Daniel Heinig is a strategic product manager at SICK. With nearly 20 years of experience in the industry, Daniel has been with SICK for eight years providing product support to customers in Germany.

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How to Improve Boiler Efficiency

By Scott A. Rouse, Sierra Instruments

In many chemical plants, the electricity the plant uses is derived from a natural gas power plant or a cogeneration plant burning waste gas streams. In large boilers (figure 1), power plants bring together air and fuel (natural gas, waste gas, oil, or coal) for combustion, which creates heat. The heat boils the water, creating steam. The steam runs through a turbine, which causes the turbine to spin, thus generating electricity.

Measuring the flow energy—flows that cost money such as natural gas, waste gas, water, and steam—in these boiler applications is critical for improving energy efficiency, identifying waste, and minimizing the greenhouse gases (GHG) going into atmosphere. Only with accurate flow measurement can users make informed decisions to improve energy efficiency.

Know your options when selecting the appropriate flowmeter technology to measure natural gas, water, and steam in power generation.

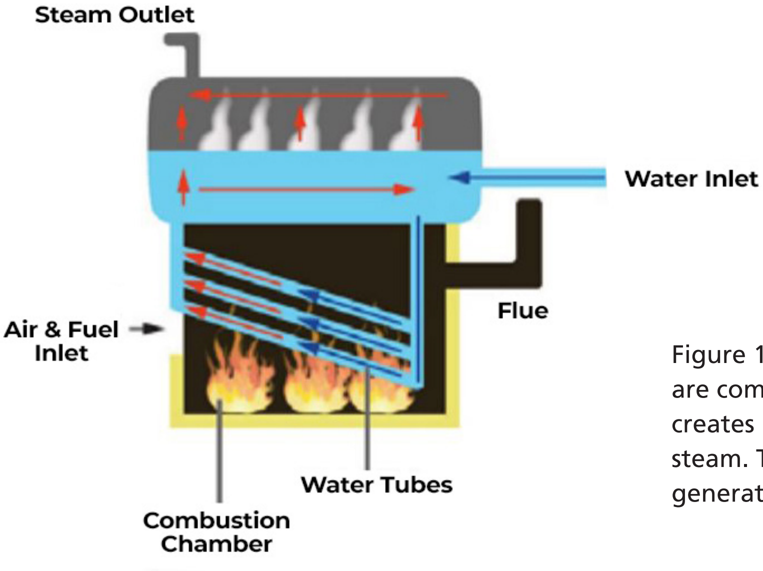

Figure 1. In typical boilers, air and fuel are combined for combustion, which creates heat to boil the water, creating steam. The steam causes a turbine to spin, generating electricity.

How do users decide which flowmeter technology is best to measure the gas, water, and steam for boiler applications? Choosing the right flowmeters depends on the fluid being measured. When discussing boiler efficiency improvements, three primary applications are involved:

1. Accurate inlet air and fuel (natural gas, waste gas, oil, or coal) measurement for efficient combustion.
2. Inlet feedwater measurement to determine steam production efficiency and identify waste.
3. Measurement of outlet steam production.

Increase combustion with optimal fuel-to-air ratio

Power generation requires inlet air and fuel (natural gas, waste gas, oil, or coal) for combustion. Engineers must measure the air and gas ratio accurately for efficient combustion in the boilers. Too much gas is wasteful, dangerous, and costly; too little will create insufficient flame to boil the water efficiently.

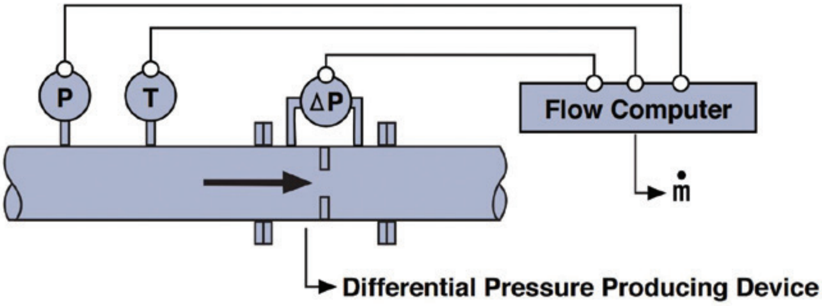

Figure 2. This is a typical differential pressure flowmeter set up with additional pressure, temperature, and differential sensors to infer mass flow.

Orifice and turbine meters. Monitoring fuel gas to the boiler units traditionally is accomplished with an orifice or turbine meter. However, these are not the best measuring devices for this application because they both are subject to failure and require frequent skilled maintenance to provide an accurate and reliable measurement. Constrained piping conditions also can give engineers headaches. For example, an orifice meter requires 10 to 50 diameters of upstream piping to eliminate the effect of flow disturbances. Because long straight pipe runs are hard to find, most flow measurement systems are affected adversely by varying flow profiles within the pipe.

The biggest cause for concern is that orifice and turbine meters measure volumetric flow. Additional pressure, temperature, and differential pressure sensors, as well as a flow computer, are required to calculate or infer mass flow (figure 2). This not only degrades the flow measurement accuracy, but the installation and maintenance costs with this type of compensated measurement increase the cost of ownership.

Thermal mass flowmeters. In contrast, thermal mass flowmeters are suitable for the direct mass flow measurement of gases, not volumetric flow. Because thermal mass flowmeters count the gas molecules, they are immune to changes in inlet temperature and pressure, and measure mass flow directly without compensation. In inlet air and gas flow boiler applications, thermal flowmeters perform well because the optimal fuel-to-air ratio for efficient combustion in boilers is calculated on a mass basis, not volumetric (figure 3).

In a thermal flowmeter's simplest working configuration, fluid flows past a heated thermal sensor and a temperature sensor. As the fluid's molecules flow past the heated thermal sensor, heat is lost to the flowing fluid. The thermal sensor cools down, while the temperature sensor continues to measure the flowing fluid's relatively constant temperature. The amount of heat loss depends on the fluid's thermal properties and its flowrate. Thus, by measuring the temperature difference between the thermal and temperature sensors, the flowrate can be determined (figure 4).

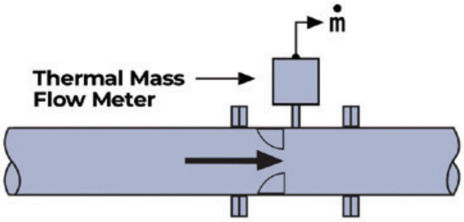

Figure 3. Direct mass flow measurement using thermal mass flowmeters.

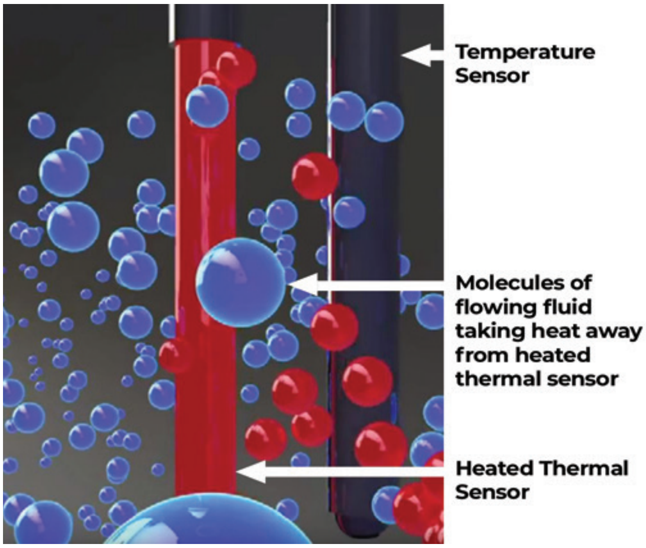

Figure 4. A thermal flowmeter determines flowrate by measuring the temperature difference between the thermal and temperature sensors.

New developments in four-sensor thermal technology coupled with stable "dry sense" sensor technology as well as advanced thermodynamic modeling algorithms enable some thermal flowmeters to attain ±0.5 percent reading accuracy, rivaling Coriolis flowmeter accuracy at less cost. Onboard software apps also enable gas-mixing capability, in-situ validation, and dial-a-pipe.

Measure inlet feedwater accurately

Water also is an expensive flow energy and limited resource. In boiler applications, it's important to measure the inlet feedwater flow to the boiler accurately because users need to measure the efficiency at which the boiler turns this feedwater into steam (figure 1).

Clamp-on ultrasonic flowmeters. While users could measure inlet water with a volumetric vortex flowmeter, clamp-on ultrasonic flowmeters are ideal for water flow applications due to their ease of use and application flexibility. They achieve high accuracy at low and high flows, save time with no pipe cutting or process shutdown and are not affected by external noise (figure 5). Advances in ultrasonic technology now have onboard software and apps that make the meter easy to install, providing a visual signal that it has been done correctly.

Figure 5: Some clamp-on ultrasonic flowmeters offer ease of use and flexibility for water and liquid flow applications.

Optimize steam production

The boiler's steam must be measured accurately to determine whether the boiler is producing the expected amount of steam or needs to be tuned for increased efficiency (figure 1). Traditionally, steam flow has been measured with a differential pressure device, typically an orifice plate.

However, such devices are inherently volumetric flow measurements. Changes in pressure and temperature will change the steam's mass flowrate. Even a "small" change of 10 percent in steam pressure will result in a 10 percent error in non-compensated mass flow. This means that, in a typical differential pressure measurement installation, the volumetric flowrate must be compensated by measuring temperature and pressure. These three measurements (ΔP, T, and P) are integrated with a flow computer to calculate mass flow.

CASE STUDY

Thermal Flowmeters Improve Boiler Efficiency at a Chemical Plant in China

Purified terephthalic acid (PTA) is the precursor to polyethylene terephthalate (PET), the ubiquitous material used worldwide in plastic bottles, textiles, and elsewhere. A PTA chemical plant in China generated steam and electricity from its onsite power plant using coal as a fuel. It also had a wastewater treatment station that produced methane, which then was flared off. Both processes are major GHG emitters.

New government regulations required the company to reduce its CO2 emissions. The plant decided to modify its four boilers to burn both coal and the previously flared-off waste gas (methane), estimating a savings of approximately $0.5 million in coal each year. Working with a single-source supplier, engineers reworked the boilers' designs and installed Sierra Instruments' industrial insertion thermal flowmeters to measure its combustion air and waste gas fuel (figure 7).

One thermal flowmeter measures the waste gas flow, while the other four thermal flowmeters provide sub-metering of this gas stream to each boiler. Another four meters measure preheated (200 degrees C, 392 degrees F) combustion air to each boiler, allowing the boiler control system to optimize the fuel-to-air ratio. The Sierra flowmeters provided both precision flow data for complying with government regulations and helped the company reduce waste while increasing efficiency.

Other potential metering applications are under review, including:

- Feedwater to the boilers using clamp-on ultrasonic flow. Because this is a pre-existing feed piping system, a clamp-on ultrasonic meter provides a flexible solution.
- Steam flow measurement. Measurement of steam flow delivered from the boilers to the turbine generator and sub-metering to the other plant processes.

Figure 7. A thermal mass flowmeter was installed at a PTA chemical plant in China to measure methane waste gas.

Figure 6. Insertion multivariable vortex mass flowmeters measure steam—one process connection for mass flowrate, temperature, pressure, volumetric flowrate, and fluid density simultaneously.

Insertion multivariable vortex flowmeters. Insertion multivariable vortex flowmeters measure steam output production from boilers more accurately (figure 6). One insertion vortex flowmeter with one process connection measures mass flowrate, temperature, pressure, volumetric flowrate, and fluid density simultaneously. Saturated steam's density varies with either temperature or pressure, while superheated steam varies with temperature and pressure, so multivariable vortex flowmeters ensure that the flowmeter's density calculations are correct, and therefore, that the mass steam flow measurements are correct.

Multivariable vortex flowmeters provide steam accuracy of ±1 percent of reading, 30:1 turndown, as well as pressure and temperature compensation. In addition, recent technology and sensor advances account for external vibration, making the vortex flowmeter even more accurate and enhancing low flow measurement. New onboard software apps also allow easy setup, tuning, trouble shooting, in-situ calibration validation, and data logging.

All images courtesy of Sierra Instruments.

ABOUT THE AUTHOR

Scott A. Rouse (s_rouse@sierrainstruments.com) is vice president of product management at Sierra Instruments.

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Texas BASF Plant Selects Coriolis Flowmeters

By KROHNE Inc.

BASF chose Coriolis flowmeter technology as the centerpiece of its Freeport plant's SIS.

BASF's Freeport, Texas, plant manufactures superabsorbent polymer (SAP), which absorbs and retains large amounts of liquids. The water-absorbing polymer has thousands of uses, ranging from diapers, masking tape, and artificial snow, to hot and cold therapy packs, motionless water beds, and even grow-in-water toys.

According to Daniel Siddiqui, BASF's instrumentation and electrical lead engineer, plant operators needed to replace flowmeter instrumentation for the safety instrumented system (SIS), an engineered set of hardware and software controls used on critical process systems. The previous mass meter equipment was under review for replacement and BASF was researching options to upgrade to newer technology. Siddiqui said, "BASF wanted to explore options that would maintain our high safety standards but were economical."

> "Operators knew that selecting the right instrumentation was critical to minimizing intermittent or false alarm trips that would result in production line shutdown."

The plant's SIS was required to meet safety integrity level (SIL) 3, a measure of system performance and probability of failure for a safety instrumented function (SIF), as defined in the IEC 61508 functional safety standards. Among other items, SIL 3 requires an SIS safety instrument with an override for unusual conditions. Redundant flowmeter instruments are required to alert operators to flow deviations and trigger a safety alarm. Every time the deviation is greater than 5 percent, the SIS shuts down the production line.

Operators knew that selecting the right instrumentation was critical to minimizing intermittent or false alarm trips that would result in production line shutdown. Apart from the economic burden from loss of production and wasted material, premature stopping under full load—rather than normal ramp down for shut off—can introduce significant equipment wear and tear.

Selecting flowmeter technology

BASF opted for Coriolis flowmeter technology as the centerpiece of its Freeport plant's SIS. With good price versus performance, smaller footprint, entrained gas management features, and in situ verification capabilities, the flowmeter technology improves reliability and decreases downtime for critical process systems.

"We reached out to KROHNE and the quote we received represented significant cost efficiencies compared to the other vendors," said Siddiqui. BASF tested the KROHNE meter at its central laboratory located in Germany and approved it for SIS service.

After reviewing a variety of options, BASF chose a design featuring two KROHNE OPTIMASS 6400 Coriolis twin bent tube mass flowmeters in series to create the required redundancy. The flowmeters are available in sizes ranging from DN 08 to 250 and can be made in stainless steel 316L, Hastelloy C22, and Duplex steel UNS S31803. The BASF installation includes 2-inch meters; the external meter is made of 316 stainless steel, while the internal unit is composed of Hastelloy.

Compliant with the User Association of Automation Technology in Process Industries (NAMUR) standard installation lengths, the selected flowmeters operate in high temperatures up to 752 degrees F (400 degrees C), as well as cryogenic applications down to -328 degrees F (-200 degrees C). It also handles pressures up to 200 bar (2,900 psi). In addition, they feature the MFC 400 signal converter, which offers fast, completely digital signal processing as well as enhanced diagnostic and status indications.

> "BASF opted for Coriolis flowmeter technology as the centerpiece of its Freeport plant's SIS."

Price versus performance and entrained gas management

Plant operators reviewing options determined that the price along with performance reliability of the selected flowmeter was superior to all other options. If operators obtained a reading showing a deviation or another issue with a process monitoring parameter, the meter helped identify the issue in advance, while performing reliably under the abnormal conditions.

In addition, the selected flowmeter offered a key advantage: entrained gas management. Entrained gas can disturb the sensitivity of mass flow measurement of liquids, decreasing accuracy or even stopping measurement completely. The Coriolis mass flowmeter technology ensures both stable and uninterrupted measurements with high gas content. The OPTIMASS 6400 provides a 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 percent gas or air content in the line, it maintains the mass density measurement continuously 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 smaller physical footprint of the meters selected was another benefit making installation easier. For example, the selected flowmeter fit into the existing space without major piping modifications, while other vendors' meters would require significant piping modifications.

With the selected flowmeter, a proprietary isolation system allows the meters to be close-coupled or mounted flange-to-flange. The unique design ensures that tube vibration has no effect on performance when meters are flange-to-flange mounted. The meters have an oscillator that moves the pipe, causing fluids to swirl, which creates a mechanical distortion between the pipe's inlet and outlet. The sensor upstream of the oscillator picks up this vibration before the outlet. With other designs, tube vibrations migrate through the piping, causing errors if the meters are close-coupled.

For the same pressure drop, BASF was able to select a smaller diameter because of the lower pressure drop through the meter compared to other options. This was a cost advantage to BASF. One other benefit BASF noted was optimizing the stocking of spare parts ensuring that all meters received have the required entrained gas capability.

> "We got excellent support from KROHNE and were able to get two meters, which allowed us to stay under our approved budget," said Siddiqui.

In-situ verification reduces downtime

Safety instrument meters must be calibrated regularly, and operators are required to establish a proof test interval. Using the OPTICHECK onsite verification tool, BASF can fulfill third party requirements for independent verification of instruments. They connect the tool inline onsite to gather measuring data to ensure the flowmeter is performing within ±1 percent of the factory calibration. The baseline can be historic repair data from the factory or onsite test results after performing a full verification. OPTICHECK also provides detailed reports for proof test documentation of safety loops.

The in-situ verification enables the operators to keep the meter operating longer, rather than having to pull the meter out of line, package it, send it to get calibrated to a known standard, and then shipping it back and installing it.

> "Safety instrument meters must be calibrated regularly, and operators are required to establish a proof test interval."

Meter performing well since startup

Plant operators started up the Coriolis meter technology for the SIS in February 2020. According to Siddiqui, the system has been operating well, providing accurate readings, and offering increased confidence in the SIS application. "By using the KROHNE meters, we did not compromise safety, and were able to maximize cost efficiencies while receiving free startup support," he said.