Know Your Gas Quality!

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In almost all long-term global energy scenarios natural gas is the fossil fuel whose share in the global energy mix is growing most significantly. However, the label "from yesterday, no longer up-to-date" is attached to the epithet "fossil". Instead, everyone is talking about alternative, so-called "green", gaseous fuels: biogas from natural or synthetic sources and hydrogen from renewable "power-to-gas" technologies. However, the latter will not be available in sufficient quantities to replace traditional natural gas for years to come. In the interconnected natural gas networks, there will therefore be more and more gas mixtures of all these sources: natural gas, conditioned biogas, LNG (liquefied natural gas), LBM (liquified biomethane), all with and without the addition of hydrogen. As a result, the gas quality can fluctuate strongly from point to point within a short time. Strong fluctuations in gas quality can also have a local origin: Boil-off gas from an LNG tank can be very different from the gas that is pumped from the bottom of the tank and vaporized, e.g. to supply a ship's engine.

In addition to these technical boundary conditions, stringent legislation on air pollution and greenhouse gas emission and stakeholders' foremost interest to operate their equipment as safely and efficiently as possible all drive the need for gas quality sensing.

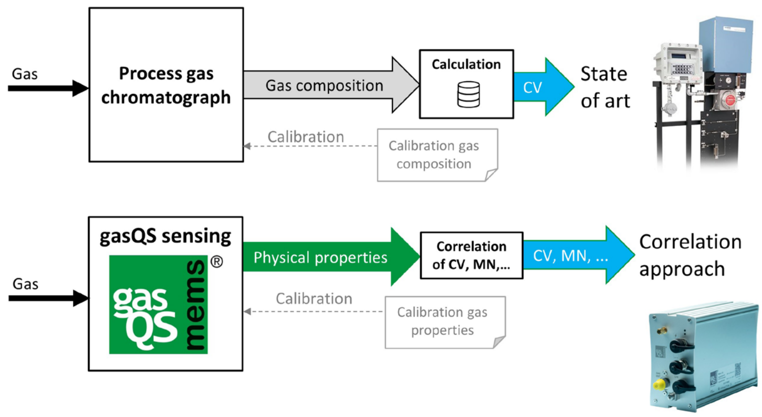

Figure 1

Gas quality sensing: the gasQS technology

The standard tool for determining the gas quality is a process gas chromatograph (PGC), which is used to determine and output the molar composition of the sample gas (Fig. 1). After the measurement, further parameters such as compressibility or calorific value can be determined with the appropriate calculation rules. PGC-based systems require a connection to a carrier and calibration gas. Acquisition and maintenance cost-intensive, space-consuming and discontinuously working (cycle times in the range of a few minutes) are adjectives of PGCs, because of which low-cost, robust alternatives are often sought in order to determine the gas quality even in places where this was previously not possible.

Mems AG offers microelectromechanical (MEMS) sensors, which meet the requirements of speed, robustness, size and price for fixed installations (gas engines and turbines, industrial burners, combined heat and power, fuel cells) and mobile control systems of natural gas vehicles (NGV). Based on a silicon chip with integrated, micro-thermal sensing head, thermo-physical properties of a gas are measured with subsequent correlation of gas quality factors such as calorific value, Wobbe index, methane number, compressibility or the air/gas ratio. No compositional analysis as in the case of PGC is performed, but at the same time, no knowledge of the gas composition is needed in the correlation approach.

Depending on the application, different sensor options are available, from stand-alone devices up to plug-and-play measurement systems (Fig. 2). Common to all variants is the ease of installation and integration into existing measurement and control systems. High contents of up to 100% of hydrogen in natural gas are no more a problem than high amounts of inert gases in bio, coal mine or LNG boil-off gas.

Applications

Gas engines and turbines manufacturers require minimum gas qualities for safe operation of their equipment. However, not only safe but also efficient operation of the machinery depends on gas quality. While the former aspect is handled with a minimum methane number to be guaranteed by the gas supplier, efficiency is not so easy to control if no gas quality measurement is available. Besides determining methane number as the

Figure 2

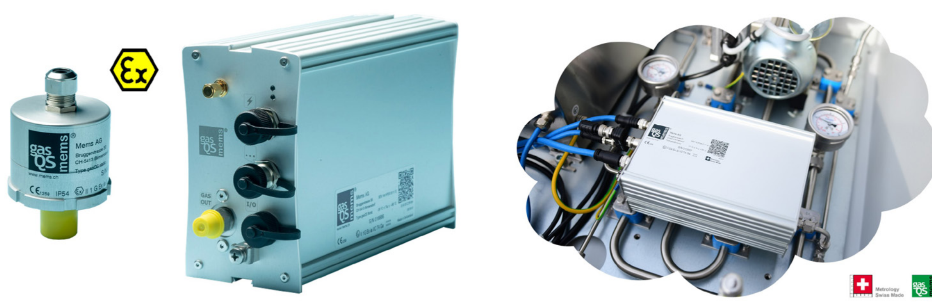

Figure 3

classical quality index, the correlation approach of the gasQS technology opens up the access to more significant engine parameters such as optimal ignition angle or exhaust gas recirculation (EGR) limit rate (https://doi.org/10.1016/j.measurement.2016.05.098) for most efficient use of the gaseous fuel.
A 400 MW coastal power plant will increase its efficiency due to the installation of an outdoor gasQS measurement system as seen in Fig. 3.

Several hydrogen injection field trials are accompanied by gasQS sensors in order to monitor in real time the distribution process of hydrogen in the local gas network. While a pair of sensors at the mixing station determines the exact amount of hydrogen added, remote sensors distributed over the local network communicate the measured gas quality via IOT-gateways to an industrial connectivity cloud that allows to manage and combine all collected data for a complete picture of the actual hydrogen concentration at any point in the network.

As in the case of hydrogen feed-in, it will be important in future to know the calorific value at every point in a gas network so that each gas customer can be billed individually for the energy supplied to him. This process is supported by reconstruction programs that calculate the gas distribution in the network based on network models. However, when implementing the system and periodically recurring, a plausibility check of the simulation with data measured at selected points of the network is necessary (Fig. 4).

If no such software tools are applicable, deployment of gas quality sensors within highly branched and widely extended gas networks can replace the time-consuming and thus cost-intensive, periodic gas sampling procedure for accounting purposes. Encrypted data is exchanged via cellular phone networks between sensors and a cloud-based hosting service where all data is stored and managed.

Some process industries, especially glass production, are sensitive to changing gas qualities. There is therefore a need for a fast gas quality sensor system that can detect such changes within a few seconds and thus be integrated into closed-loop control systems. Due to their small mass, chip sensors are predestined for fast measurements in comparison to process gas chromatographs, where a new measurement value is due only every few minutes.

Conclusions

Gas quality sensing is no more a nice but rather need to have add-on to all process equipment that has to cope with the increasingly varying gas quality. Ready solutions for gas network operator, gas power plant managers, engine operators or process industry owners are available at low capital and operational expenditure compared to traditional process gas chromatographs. The correlation approach of Mems AG allows not only the measurement of standard gas qualities namely calorific value or methane number, but also process-specific parameters such as optimum ignition angle for gas engines or the monitoring of the mixing process when feeding hydrogen into natural gas networks. •

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Figure 4