Hydrogen Analysis

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Hydrogen (H2) has been identified as an alternative clean fuel source. It can be used directly to power fuel cells, and even when burned only produces water as a byproduct. There are several challenges associated with measuring hydrogen, from production through to its various uses. Spartan Controls has several solutions available for hydrogen analysis in different applications.

Common Ways to Measure Hydrogen

Two properties commonly exploited for measuring hydrogen are density and thermal conductivity.

Hydrogen's density is much less than that of other gases, so a density measurement can be used to infer the amount of hydrogen in a binary mixture – where the density of the other gas is known. The MicroMotion Gas Specific Gravity Meter (SGM) provides a highly accurate and fast measurement of the specific gravity of a gas. It is commonly used in applications such as hydrogen cooled generators and the measurement of refinery fuel gas.

Fig. 1 - MicroMotion Gas Specific Gravity Meter

MicroMotion SGM	
Accuracy	+/- 0.1% of reading
Repeatability	+/- 0.02% of reading
Response Time	<5 seconds

The thermal conductivity of hydrogen is also much greater than that of other gases, and a measurement of the thermal conductivity of the gas can be used to infer the hydrogen concentration in a binary mixture. The Rosemount X-STREAM Enhanced analyzer provides a thermal conductivity sensor that can be used for hydrogen measurement. Common applications include syngas measurement, and hydrogen blending into natural gas.

Gas Chromatographs (GCs) are typically used to measure the complete composition of a gas, including hydrogen. A Rosemount 700XA Gas Chromatograph provides a highly accurate way to measure hydrogen. Applications can include hydrogen in natural gas, syngas, and fuel gas measurement.

Fig.2 - Rosemount X-STREAM Enhanced

Measuring Produced Hydrogen

Hydrogen is frequently produced through Steam Methane Reforming (SMR), but can also be produced through other means such as Electrolysis. In both cases the hydrogen concentration is typically monitored. A Rosemount X-STREAM Enhanced analyzer provides multicomponent measurement using a thermal conductivity detector combined with other sensors such as infrared, paramagnetic, and electrochemical sensors.

This allows for the measurement of complex mixtures such as syngas, with CO, CO2, CH4 and H2 all present in large quantities. The X-STREAM provides online compensation of the thermal conductivity detector and the infrared detectors to provide a highly accurate online measurement of those four components within the mixture. Similarly, hydrogen and oxygen can be monitored together to monitor the efficiency of an electrolyzer.

Purification of Hydrogen

Raw hydrogen is sent through a purification process to meet specs for its use. Common specifications are for high purity hydrogen (99.99% or greater) coming out of a Pressure Swing Absorption (PSA) process unit. Even higher specifications are required to meet fuel cell quality hydrogen, such as SAE J7219. In these cases, the most accurate measurement of the purity is to measure the impurities that are left. These are usually CO, CO2, CH4 and H2O.

The Rosemount CT5800 Multi-Gas Spectrometer is able to measure all these components to sub-ppm levels to meet these specifications.

CT5800 Hydrogen Purity (Typical)		
Component	*Range*	*LCO*
CO	0 - 5 ppm	0.05 ppm
CO2	0 - 5 ppm	0.02 ppm
H2O	0 - 10 ppm	0.1 ppm
CH4	0 - 50 ppm	0.5 ppm
NH3	0 - 10 ppm	0.05 ppm

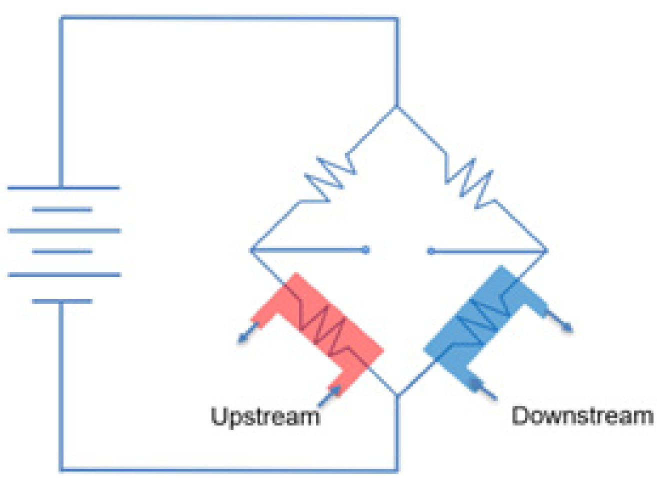

Fig. 3 - Thermal Conductivity Detector arrangement for hydrogen blending

Natural Gas Blending

Hydrogen blending into natural gas is done in an effort to reduce the carbon intensity of the natural gas when its burned. Many utilities and pipelines are considering blending hydrogen at concentrations from 1-20% into natural gas.

To control this process, a thermal conductivity analysis can be used. Natural gas variability can create errors in hydrogen measurement when using a standard thermal conductivity analyzer.

Instead, the Rosemount X-STREAM Enhanced analyzer has a setup that allows for a flowing reference. This detector uses a sample from the upstream natural gas as the reference, and compares the difference in thermal conductivity to a sample of gas downstream of the blend point. The difference between the readings is directly due to the addition of the hydrogen.

Prior to injecting the blended gas into the pipeline, a GC is used for accurate fiscal measurement and ensuring pipeline spec is met. This will measure the BTU of the gas, and provide another hydrogen reading.

GCs used for measuring natural gas use a thermal conductivity detector with helium as the carrier gas. This means helium is used as the reference gas on the thermal conductivity detector. However, helium as a reference and carrier gas does not provide an accurate hydrogen measurement beyond 10% hydrogen in natural gas. To get a good measurement into higher ranges, a dual detector and dual carrier gas setup is required.

The Rosemount 770XA Gas Chromatograph provides a setup using argon as a carrier and reference gas for the hydrogen measurement, and helium as the carrier gas for the natural gas measurement. This provides a highly accurate measurement of the BTU and hydrogen concentrations from 0-20% or higher hydrogen in natural gas.

Typical 770XA Measurement Ranges	
Methane	65 - 100%
Ethane	0 - 20%
Propane	0 - 10%
n-Butane	0 - 5%
i-Butane	0 - 5%
n-Pentane	0 - 1%
i-Pentane	0 - 1%
neo-Pentane	0 - 1%
Hexane +	0 - 0.5%
Nitrogen	0 - 20%
Carbon Dioxide	0 - 10%
Hydrogen	0 - 20% (higher ranges optional)

Conclusion

The increasing market demand for hydrogen means there's an increased need for its quantification. Spartan Controls has several unique solutions for measuring and analyzing hydrogen concentrations. Contact Spartan Controls for more details.

Fig. 4 - 770XA Rosemount Gas Chromatophraph