APPLICATION REPORT

Iron, Steel & Metal

High temperature flow measurement of CO_2 and H_2 from a reactor column

- Improving sustainability and decreasing the carbon footprint of steel production
- Ultrasonic flow measurement to monitor H_2 and CO_2 separation from flue gases
- Real-time measurement of various gas mixtures at high temperatures

TNO innovation for life

1. Background

TNO is an independent Dutch research organisation focussed on developing knowledge and innovations for practical applications. Together with their partners, TNO initiated the STEPWISE project to demonstrate the cost-effective carbon dioxide (CO_2) capture from residual gases in the steel industry and to create value from the energy content of the flue gases. The technology demonstrated in this project helps the steel industry reduce their CO_2 footprint and improve sustainability. The project is supported by the European Horizon 2020 Low Carbon Energy programme.

One type of flue gas in steel production is blast furnace gas (BFG). It is a by-product of the iron ore reduction process in blast furnaces and it is commonly used as a fuel in steel works or is used in boilers and power plants. The heating value of the BFG is quite low as it mainly consists of nitrogen (55 %), carbon monoxide (25 %), carbon dioxide (20 %) and hydrogen (2…4 %).

In Luleå, Sweden, STEPWISE demonstrates in a steel plant how to achieve the removal of 14 t/day of CO_2 from the blast furnace gases and to make a hydrogen-rich stream available. The captured CO_2 can be transported and stored (CCS) or can be used as feedstock for the production of synthetic methanol, which can serve as a fuel in the steel plant. The hydrogen-rich stream can be used as fuel for power plants or as feedstock for the production of ammonia.

KROHNE

2. Measurement requirements

In the STEPWISE demonstrator project, the innovative Sorption Enhanced Water Gas Shift (SEWGS) process is applied. The process is fed with a flue gas mixture from the steel plant. In a first step carbon monoxide (CO) is converted into CO_2 and hydrogen (H_2) by reacting with steam via the water-gas-shift (WGS) reaction. For BFG this results in a reduction of the CO content from 25 % to 5 %.

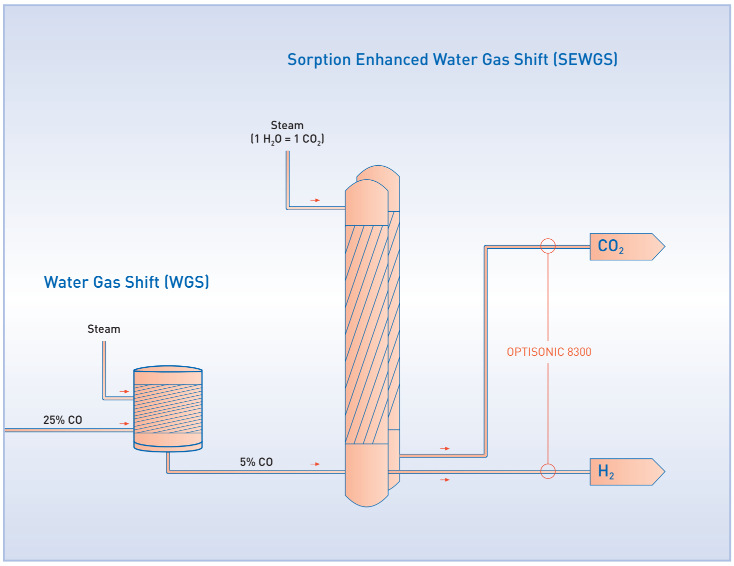
In a subsequent step the gas mixture enters the SEWGS reactor where the remaining CO is converted to CO_2 and H_2. In this process step a solid adsorbent is used which binds the produced CO_2 and as a result a hydrogen-rich stream leaves the reactor.

The SEWGS process operates at increased temperature and pressure, up to +540 °C / +1004 °F and 50 bar / 725 psi. The moment the sorbent is saturated with adsorbed CO_2, regeneration is performed via a combination of pressure release and steam purge. In this way, a CO_2-rich stream is obtained by condensing out the steam. The SEWGS process results in a separate H_2-rich stream and a separate CO_2-rich stream, leaving the reaction column it two different pipelines.

To assess whether the gases have always been successfully separated and to know how much CO_2, H_2 (plus nitrogen) and steam leave the column, TNO needed suitable flow instrumentation. It was required that the flowmeter provides real-time measurement of high temperature gases up to + 540°C / +1004°F, while offering a high degree of flexibility to deal with fluctuating gas compositions and different gas mixtures. Given that the CO_2 gas leaves the column at very low pressures, pressure loss was not an option.

3. KROHNE solution

The OPTISONIC 8300 ultrasonic flowmeter turned out to be the perfect fit for this challenging application. Designed for flow measurement of high temperature gas mixtures and a track record in steam applications, the gas flowmeter fully met all technical specifications and was welded into the CO_2 line (DN100) and the H_2 line (DN125). Any changes in terms of installation design were not necessary.



Schematic of STEPWISE process with the OPTISONIC 8300

Utilizing the ultrasonic differential transit-time principle, the OPTISONIC 8300 is able to measure different gas mixtures independently from the gas composition. It allows for real-time flow measurement, which is particularly crucial when it comes to detecting transition phases of the gas mixture ratio. This enables the operator to measure all gas batches without any loss of measurement values. The outgoing volumetric flows are recorded by an analyser and linked to the time at which the flowmeters pass on the readings to the PLC.

4. Customer benefits

Helping the customer assess how efficient their separation process is, the KROHNE gas flowmeter plays an important role in optimising the SEWGS process. The OPTISONIC 8300 enabled TNO to continuously measure the outgoing flows even with the gas composition changing during the time of a batch. This was particularly crucial to the operator as the process can be optimized this way without installing additional flow instrumentation, which can be a tremendous cost factor. Due to the real-time measurement of the KROHNE flowmeter, no measuring values are lost, even during transition phases.

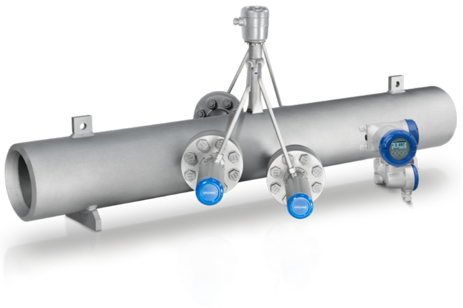
In terms of pressure loss, the customer benefitted from the full-bore design of the OPTISONIC 8300. The flowmeter has no moving parts or obstructions and causes virtually no pressure loss, which saves on pump capacities and energy costs. Another major advantage for TNO is the maintenance-free design of the ultrasonic flowmeter. It is not subject to wear or contamination. Given that TNO's processes need to be stopped occasionally, deposits can precipitate. Accuracy and signal strength, however, are not affected by deposits, so recalibration of the flowmeter is not necessary and allowed it to be directly welded into the pipes.

The OPTISONIC 8300 once again proved to be a reliable high-performance meter for CO_2 and H_2, which makes it a solid option in follow-up projects. The KROHNE flowmeter even enables the customer to determine the gas composition of two mixed gases based on the velocity of sound. Though currently not an issue for TNO, real-time analysis of the gases that pass through the pipes would be possible just yet without additional flowmeter installation, making the OPTISONIC 8300 not just a flowmeter, but a compact device for the real-time analysis of gas compositions.

Ultrasonic flow measurement of a high temperature hydrogen/steam mixture

5. Products used

OPTISONIC 8300



- Ultrasonic flowmeter for superheated steam and high temperature gases
- 2-path meter with optional mass flow and enthalpy calculation
- Integrated flow computer option, current inputs for external pressure and temperature sensors
- Bi-directional flow measurement over a wide dynamic range
- Full bore design: No moving parts, no wear, no pressure loss
- Extensive online diagnostics and functions for proper meter operation and verification
- Up to +620°C / +1148°F; Higher temperature and pressure ranges on request
- Ex zone 0 approval up to +600°C / +1112°F
- DN100...1000 / 4...40"; max. PN250 / ASME Cl 2500

Contact

Would you like further information about these or other applications?
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