AMETEK®
PROCESS INSTRUMENTS

APPLICATION NOTE

USING TUNABLE DIODE LASER ABSORPTION SPECTROSCOPY (TDLAS) FOR CARBON DIOXIDE MEASUREMENTS IN LIQUIFIED NATURAL GAS PROCESSING

The liquefied natural gas (LNG) plant is a large and complex industrial facility. The liquefaction process, which transforms natural gas to liquid, involves operations at very low temperature. At these conditions carbon dioxide (CO_2) can freeze on the exchanger surface, plugging lines and reducing plant efficiency. The natural gas entering the liquefaction plant will often contain several contaminants that must be reduced to ensure satisfactory LNG plant performance and to meet LNG sales specifications.

The liquefaction process involves the removal of components such as acid gases, helium, water, and heavy hydrocarbons. Acid gas removal is the next important step, reducing CO_2 levels to about 50 parts per million by volume (ppmv) to meet normal sales gas specification. There are many acid gas treating processes available for the removal of CO_2 from natural gas. The selection of these processes is based not only on economic feasibility but also the effective removal of CO_2.

These processes include chemical solvents, physical solvents, hybrid solvents, adsorption processes and physical separation based on membrane systems. Each of these technologies has advantages and limitations. The nature and amount of contaminants in the feed gas, as well as the targeted removal capacity, the amount of hydrocarbons in the gas, the amount of gas to be processed, and the desired selectivity, should all be considered. Despite the nature of the process used to purify the natural gas, optimization of the process requires measurement of the CO_2 before and after purification.

Amine gas treating refers to a group of processes that use an aqueous solution of various amines to remove hydrogen sulfide (H_2S) and CO_2. Today it is a common process used in refineries, petrochemical plants, and natural gas processing plants. The use of blended amines in gas treatment provides significant improvement in the absorption capacity, absorption rate and in meeting solvent regeneration energy requirements. In most cases the amine mixtures contain methyldiethanolamine (MDEA) as the base amine, with the addition of either one or two more reactive amines such as monoethanolamine (MEA) or diethanolamine (DEA).

AMETEK 5100HD TDLAS ANALYZER

The typical amine treatment unit involves two stages. The first stage is the amine contactor, where natural gas is brought into contact with amine. In the absorber, down-flowing amine solution absorbs H_2S and CO_2 from the up-flowing sour gas to produce a sweetened gas stream with significantly reduced acid components. Sweet gas leaves the top of the absorber and flows to a dehydration unit before liquefaction. The resultant rich amine, with absorbed CO_2 and H_2S, then flows to the regenerator, which is a stripper with a reboiler. In the second stage, H_2S and CO_2 are stripped from the liquid phase to regenerate the lean amine solution, which is returned to the amine contactor column. The general process flow diagram for amine CO_2 removal is shown in Figure 1.

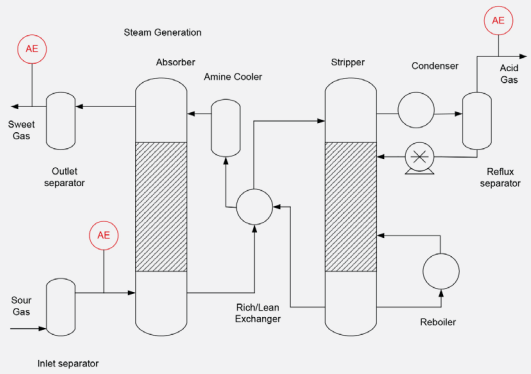

Figure 1. Amine CO_2 removal process

Acid gas and steam pass through a condenser, where the steam is condensed and cooled and returned to the top of the stripper as a reflux. Acid gas is separated and sent to the flare or compressed for the sequestration process. The acid gas leaves through the top of the stripper column. The lean amine from the bottom of the stripper is returned to the absorber through the heat exchanger and the cooler. There are several control points for the measurement of the CO_2 level for process optimization. These control points correspond to sour gas at the inlet of the absorber, sweet gas at the outlet of the absorber, and to the level of CO_2 in acid gas. Usually the concentration range of CO_2 in sweet gas varies in the range of 0 to 50 parts per million, the levels of CO_2 in sour gas correspond to the 0 to 5% range and the concentration of CO_2 in acid gas can vary in the range of 0 to 50%.

TUNABLE DIODE LASER ABSORPTION SPECTROSCOPY FOR MEASURING CARBON DIOXIDE

Tunable diode laser absorption spectroscopy (TDLAS) is a non-contact analysis technique with long-term stability, high specificity and selectivity. Laser-based CO_2 sensors offer the advantage of faster response time, large dynamic range and low drift in comparison with conventional techniques such as gas chromatography (GC). In applications like monitoring CO_2 in LNG processing plants, these attributes help meet requirements and optimize plant operations.

The AMETEK 5100HD is an extractive-type CO_2 analyzer designed for hot/wet sample analysis. There is no sample conditioning for the analyzer system, just fully integrated sample handling to transport the sample. The 5100HD uses a sealed reference cell for continuous on-line analyzer verification and offers high specificity and sensitivity. The analyzer uses a digital implementation of wavelength modulation spectroscopy (WMS), so changing the experimental protocol is simply a matter of uploading a file. Ethane (C_2H_6) has spectral interference with CO_2 near the CO_2 lines selected for measurements. Depending on the concentration of C_2H_6 in the natural gas measurements of CO_2, the concentration range 0 to 50 ppmv can be measured in near-infrared (IR) range (for concentration of C_2H_6 less than 7%) or in IR range (for concentration of C_2H_6 higher than 7%).

MEASUREMENT RESULTS

Measurement of CO_2 in the NIR range was performed with a distributed feedback laser (Figure 2). The output of the laser was coupled into single mode optical fiber which was connected to a fiberoptic beam splitter. The splitter was used to divide the optical power in a 50/50 ratio for use in the sample and reference measurements, respectively. Gradient refractive index (GRIN) lenses were used to collimate the output of the single-mode fibers and direct the resulting beams through the sample and reference cells. The sample and reference cells each contained in gas-photodiode detectors, which were connected to separate input channels of the electronics unit. With this configuration, it was possible to make simultaneous measurements of unknown samples and known references, which were used to lock the output wavelengths for the laser. It should be noted that configuration of the sample cell compartment, included two cells for the measurement of CO_2 in two different streams (measurement of the inlet and outlet of the acid removal unit is also available). The optical path of the sample cell could be adjusted, corresponding to concentration range of measured CO_2 including multi-pass Herriott cells used for low concentration range measurements.

Measurements in the IR range were organized in a similar optical set up (Figure 3). An interband cascade laser was used as a radiation source. The beam was collimated and sent to the sample cell with an optical path of 10 cm. Indium arsenide antimonide photovoltaic detectors were used in sample and reference channels. As in the previous example, electronics provided control of the injection current and temperature of the laser.

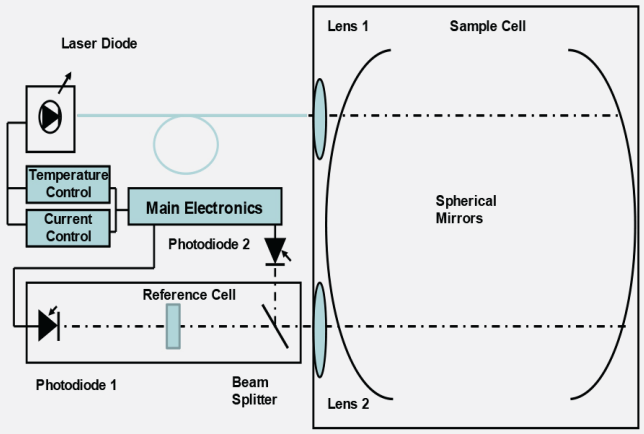

Figure 2. 5100HD analyzer optical setup for low CO_2 levels measurement in the NIR range

The data shown in Figure 4 represents the response of the instrument to a series of CO_2 challenges in the concentration range of 0 to 50 ppmv. The duration of each of the challenges was from 10 to 20 minutes with return to the zero gas baseline, which was represented by CH_4 between challenges. The speed of the response T90 time was 100 seconds and was determined by the propagation of the gas in the sampling system with a flow rate of 1L/min. The data acquisition rate was 2 seconds/measurement. Repeatability of the CO_2 readings on each of the challenges was about 0.5 ppmv of the CO_2 concentration. The value of the accuracy evaluated at the levels of CO_2 from 0 to 50 ppmv was 1.5 ppmv.

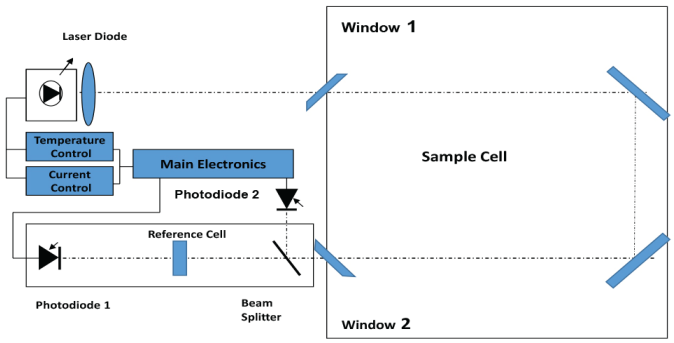

Figure 3. 5100HD analyzer optical setup for low CO_2 levels measurements in the IR range

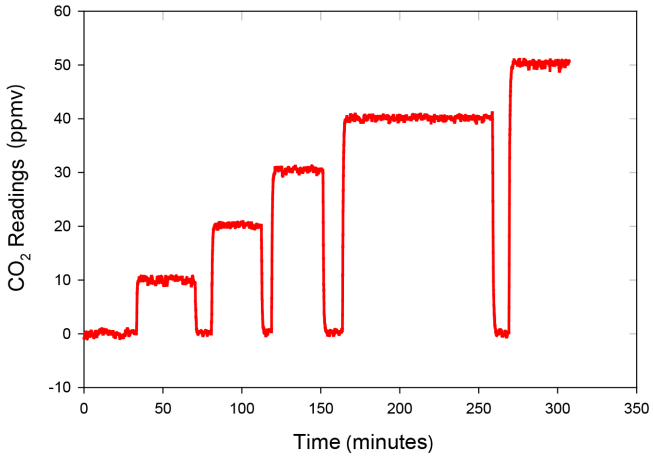

Figure 4. Response of the 5100HD analyzer to a series of CO_2 challenges

SUMMARY

To provide accurate measurements of CO_2 in natural gas it is important to account not only for CH_4, but also other components of the natural gas stream – especially C_2H_6 – and their effect on CO_2 readings. These components were accounted for by including them in the corresponding calibration model based on multivariate regression.

The advantage of using TDLAS-based technology for CO_2 measurements in the natural gas stream, compared with GC is speed of response and low maintenance value. Additionally, TDLAS provides higher accuracy and selectivity of measurements in comparison with NIR and IR photometry.

SALES, SERVICE & MANUFACTURING

USA - Pennsylvania
150 Freeport Road
Pittsburgh PA 15238
Tel: +1 412 828 9040
Fax: +1 412 826 0399

USA - Delaware
455 Corporate Blvd.
Newark DE 19702
Tel: +1 302 456 4400
Fax: +1 302 456 4444

Canada - Alberta
2876 Sunridge Way NE
Calgary AB T1Y 7H9
Tel: +1 403 235 8400
Fax: +1 403 248 3550

WORLDWIDE SALES AND SERVICE LOCATIONS

USA
Tel: +1 713 466 4900
Fax: +1 713 849 1924

Brazil
Tel: +55 19 2107 4100

France
Tel: +33 1 30 68 89 20
Fax: +33 1 30 68 89 99

Germany
Tel: +49 2159 9136 0
Fax: +49 2159 9136 39

India
Tel: +91 80 6782 3200
Fax: +91 80 6780 3232

Singapore
Tel: +65 6484 2388
Fax: +65 6481 6588

China
Beijing
Tel: +86 10 8526 2111
Fax: +86 10 8526 2141
Chengdu
Tel: +86 28 8675 8111
Fax: +86 28 8675 8141
Shanghai
Tel: +86 21 5868 5111
Fax: +86 21 5866 0969

AMETEK® PROCESS INSTRUMENTS

One of a family of innovative process analyzer solutions from AMETEK Process Instruments.
Specifications subject to change without notice.