Geophysical Research Abstracts,
Vol. 10, EGU2008-A-04748, 2008
SRef-ID: 1607-7962/gra/EGU2008-A-04748
EGU General Assembly 2008

Photoacoustic detection systems for biogas applications

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Biogas is one of the most important renewable energy source that is produced by bacterial conversion of organic matter through anaerobic digestion. Biogas as a popular reproducible energy source in the near future can substitute natural gas in heat and electricity production or as fuel for machines. Biogas is generally a mixture of methane (50-70 %) and carbon dioxide (25-50 %) but it contains smaller amounts of hydrogen (1-5 %), nitrogen (0.3-3 %), hydrogen sulfide (20-20000 ppmv), water vapor and other impurities. Hydrogen sulfide is one of the most problematic contaminant because it is toxic and together with water vapor avoids corrosion of combustion engines. Additionally, combustion of H_2S leads to SO_x generation in the flue gas which is harmful to the environment. Thus removal and monitoring of hydrogen sulfide from biogas is required for environmental health and for safety and operational reasons. Other applications also need the continuously monitoring components of biogas. One of these applications is the detection of the main components (CH4 and CO2) of the gas before the gas engine because it is the main parameter for the mixing device which adjusts the optimal gas mixture for the gas engines. The monitoring of the exhaust gas of gas engines is also an important application not only required for environmental reasons because it can provide information from the operational conditions.

For biogas applications a family of photoacoustic (PA) measuring systems was developed (Wasul-Bio). The PA systems uses single mode, fiber coupled, room temperature operated, telecommunication type, distributed-feedback (DFB) diode lasers in the near

infrared wavelength range. The PA systems can be operated in harsh industrial, potentially explosive areas.

The photoacoustic method is one of the simplest optical methods, it can be easily automated. The photoacoustic measure system enables the use of small sample volumes (several cm^3) which cause very short response time. Photoacoustic has proven to be one of the best analytical techniques for the identification and quantitative determination of trace constituents in gas mixtures This simple method has high sensitivity, suitable for detection several gases at ppm or ppb level. Like other optical method photoacoustics has high selectivity and specificity. The method has a uniquely wide dynamic range; through five to six orders of magnitude the photoacoustic signal depends linearly on the concentration of the measured gases. The Wasul-Bio instruments are able to follow quick and heavy concentration fluctuations or small changes of large concentrations. We have developed and deployed several photoacoustic measuring systems at different natural gas processing plants. The results of their operation demonstrate the high reliability of these systems. With Wasul-Bio system we have measured the contaminants of biogas at biogas plants and also monitored the exhaust gas of the gas engines.