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Fiberoptic Gas Monitoring of Flexible Risers

Nick Weppenaar, NKT Flexibles, and Anatoliy Kosterev, Lei Dong, David Tomazy, and Frank Tittel, Laser Science Group - Rice University Houston

Abstract

This paper presents a new advancement within the field of optical gas measurement with applications to the monitoring of gases inside the annulus of flexible risers used in the offshore industry. This advancement is based on the novel Quartz-Enhanced Photoacoustic Spectroscopy (QEPAS) technology. Specifically, we report on the first demonstation of such a gas sensor system using a spectraphone (a module for detecting laser-induced sound) consisting of a quartz tuning fork (QTF)/microresonator assembly and two commercial single frequency diode lasers operating at λ =1.58 μm for detecting H_2S as well as CO_2 and at 1.65 μm for detecting CH_4. A minimum detectable H_2S concentration of 10 ppmv (parts per million by volume) at the 1σ level was obtained for t=1 s averaging time, scaling down as $1/t^{½}$ up to 1000 s (verified) This implies that a 100 s sampling time will result in a minimum detectable concentration of 1 ppm. For CO_2 and CH_4, the minimum detectable concentrations were 270 and 1.5 ppm, respectively. The measurement technique will be described and test results will be presented along with implications for the field of riser condition monitoring.

This system will allow continuous monitoring of the annulus chemical environment in flexible risers. Current gas monitoring solutions are either offline with a low sampling frequency or require cumbersome EX protection near the pipe (gas chromatography). By contrast, the proposed technique will allow a compact sensing unit connected only with fiberoptics that can monitor annulus gas levels continuously and with high accuracy.

Laboratory test results show a high level of measurement accuracy even over short timescales. These results show a clear advantage over conventional systems due to the real-time sampling, and the compact final design being free of electrical leads allows for a compact bolt-on solution which can be installed almost anywhere without compromising working space. This also minimises the number of work-hours necessary near the pipe to maintain the monitoring system.

Wells may change fluid composition in a way which brings the problem of corrosion fatigue to a riser never intended for these conditions. For example, wells which initially were sweet may become sour over time. Having a gas monitoring solution in place will allow for real-time risk assessment as well as a warning system for changes in riser annulus conditions. For sour service pipes, a gas monitoring solution will allow up-to-date and highly precise corrosion fatigue calculations. Combining the input from gas monitoring with the data from other sources, such as strain and temperature monitoring, will give unprecedented insight into the field service conditions of a riser, yielding a far greater level of operating safety than previously feasible.

Introduction

The need for monitoring of flexible risers is becoming ever more apparant as oil exploration moves to greater depths and wells can be hotter and more sour than seen so far. In this situation where the limits of pipe design need to be reliably expanded, continuous monitoring of pipe health becomes a priority.

Internal and external monitoring of pipe strain and temperature are on their way to becoming established technologies (Weppenaar and Kristiansen 2008) with all the operational safety and lifetime extension these technologies enable. However, the field of annulus gas monitoring has so far been lagging, in that no accurate sensing technology which is continuous, accurate and free of electrical leads has existed. Monitoring of annulus gas levels can be vital to a reliable estimate of pipe