DAS Technology Expands Fiber Optic Applications for Oil, Gas Industry

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Distributed acoustic sensing technology expands the applications for fiber optics use in the oil and gas industry.

The digitization and automation of oil and gas technology and growing need for efficiency, productivity and safety in operations offers more opportunities for the use of fiber optics in oil and gas.

Fiber optics has been in use in the oil and gas industry since the 1990s in the form of distributed temperature sensing (DTS). DTS already is established as a well monitoring technique, according to a 2014 report by research firm VisionGain. But one kind of distributed fiber optic sensor – distributed acoustic sensing (DAS) – has been proven over the past five years in pipeline surveillance and monitoring systems. This type of sensor looks poised to add value to distributed fiber optic sensor monitoring solutions for wells and reservoirs, which will be the primary market for this technology in the future.

According to VisionGain, the complementary application of a DAS interrogation enhances the future business case for distributed fiber optic sensing. DAS also represents an opportunity for the industry to more effectively manage and optimize its resources.

"The rise of expensive multi-lateral hydraulic fracturing, an ever-greater focus on improving oil recovery and the continued strength of capital expenditure on thermal enhanced oil recovery techniques provide the main markets for the uptake of distributed fiber optic sensing over the next 10 years," said VisionGain in the report.

OptaSense, part of UK-based QinetiQ, a research and development firm focused on defense technology, was formed in 2007 to exploit the applications DAS technology. The company's technology is deployed to the end of existing fiber optics already deployed in a well, allowing acoustic data to be away and then transferred to the cloud for analysis. This data is then turned into actionable information for the customer, said David Hill.

The company focuses on three areas: oil and gas pipelines, downhole well sensing to monitor production, and sensing to enhance seismic interpretation. The company has been primarily focused on upstream, land-based North America wells. Interest in DAS really started to take off when companies began drilling horizontal wells and hydraulically fracturing these wells in shale plays. The company then moved into vertical wells and into SAGD [steam-assisted gravity drainage] wells in northern Canada. Hill said the company is now looking at applications for its technology offshore, and has done a number of jobs in the U.S. Gulf of Mexico.

OptaSense initially worked exclusively with Royal Dutch Shell plc to develop DAS technology through an agreement signed in 2009. In September of last year, the companies announced that they had delivered the world's first permanent fiber-optic DAS in-well production flow monitoring system in North America.

While the company still works extremely close with Shell, it has started collaborating with other energy companies. OptaSense and Weatherford International plc announced April 28 they had formed a strategic alliance to deliver integrated optical sensing solutions to optimize well planning, construction and production across the oil and gas asset lifecycle.

The partnership will combine OmniWell in-well optical production and reservoir monitoring systems from Weatherford with OptaSense's distributed acoustic sensing technology, including DAS-VSP vertical seismic profiling, DAS-HFP hydraulic fracture monitoring and DAS-Flow production flow monitoring. The two companies are both providers of optical reservoir monitoring systems worldwide, installing and monitoring optical sensing solutions for over 1,000 wells.

Weatherford's sensing technology includes pressure and temperature gauges, distributed temperature sensing, array temperature sensing, flow measurement and seismic sensors. The combination of Weatherford's sensing technology with DAS technology from OptaSense will deliver enhanced data acquisition and monitoring of seismic activity, well construction, completion and fracture operations and production flow.

"In addition to acquiring accurate data in real-time, OptaSense DAS technology can also reduce data acquisition costs by eliminating the need for well intervention," said Magnus McEwen-King, managing director of OptaSense, in an April 28 press statement.

The past several years, oilfield service firm Halliburton has done quite a bit of investing in DAS. Eric Holley, fiber optic product manager, told Rigzone that the company sees a lot of promise for applications specifically in seismic sensing surveys and acquisition for doing stimulation and life of well production profiling. In 2013, the company acquired the assets of DAS provider Optiphase Inc. After concluding the acquisition, Halliburton refocused the acquired assets on upstream oil and gas applications.

The results of the adoption of telecom grade fiber optic technology in oil and gas during the late 1990's and early 2000's weren't positive, said Holley. Once the oil and gas industry started purpose-building fiber optics to withstand high temperatures downhole, the use of fiber optics in heavy oil and unconventional resource plays began to take off around 2010

Halliburton has been targeting its use of fiber optics for offshore and onshore unconventional and heavy oil. On the hydraulic fracturing side, the company has been doing a lot of injection flow profiling, using both DTS and DAS to determine placement of the fluids in the wellbore. On the production side, Halliburton is using fiber optics to replace the traditional production log. This is something Halliburton has done for nearly a decade.

"In heavy oil, from the DTS, when you have massive temperature fluctuations due to steam injection, that is a tremendous environment for fiber optics to provide value. In unconventional plays, Halliburton has used fiber to monitor injection and production for life of well monitoring," said Holley.

The end goal of this analysis is to provide results that impact decision making. For unconventional plays, the focus is often on identifying optimized fracture and wellbore spacing. This can be accomplished by using the fiber optic data to further constrain and calibrate existing fracture and reservoir models.

Halliburton sees a lot of promise for DAS solutions to replicate and replace traditional geophone measurements for seismic profiling, said Holley.

The company is always seeking ways to improve DAS data quality and break down the information to a more useable and digestible form.

"There are still gaps in taking that information and making it useable, but we are working on closing those gaps and a continuing development effort."

Halliburton plans to continually close those gaps as the technology matures.

"In today's environment, changes to the wellbore need to be made to include fiber and make fiber more of a bolt on solutions, not purpose built," said Holley. "We're are making fiber a solution that is more repeatable in wells. This is from both an operational perspective and data analysis and interpretation perspective."

Advantages of Fiber Optics

One widely cited key advantage of fiber optics is the fact is that fiber optics are immune to electromagnetic interference.

"Certainly, around electrical submersible pumps and major pieces of subsea electrical equipment, there is potential for interference with the operation of an electrical gauge," said Andrew Strong, head of oil and gas technology at product development firm Cambridge Consultants, in an interview with Rigzone. "This risk is minimized with careful design of electrical sensors and their communications schemes but disappears entirely with optical sensors."

Optical fiber can act as both the sensing element and the transmission medium to and from the interrogator. In distributed fiber sensors, an optical fiber – which normally is a few miles long and housed inside a cable – is connected to an optoelectronic interrogator.

“The interrogator then launches optical pulses into the fiber,” said Strong. “As the optical pulses propagate along the core of the fiber, they interact with the material of the core and a small fraction of optical power is scattered, propagating back towards the interrogator.”

The interrogator then analyzes this backscattered signal as a function of time and, depending on configuration, is then able to discriminate temperature, strain or acoustic signal as a function of distance along the fiber.

Optical fiber sensors also allow operators the ability to multiplex. Certain types of optical fiber sensors can be connected together on a single optical fiber and their individual return signals discriminated either through the use of different optical wavelength bands, similar to radio channels. This is called wavelength division multiplexing.

“The alternative is to use the individual time-of-flight to the different sensors, which are installed at different positions along a fiber, or time division multiplexing.”

Popular sensors such as Fiber Bragg Gratings can be multiplexed using either technique.

The use of fiber optics also makes more sense for complex installation work further offshore and in high pressure, high temperature environments. Optical sensors deployed downhole or for asset monitoring are inherently simple and are almost single components so that failure rates are low. In general, the economics of optical sensors improve as monitoring distances and/or the number of measurement points grow. By contrast, incorporating electrical sensors into a cable is complex, and raises costs while reducing reliability.

“This is important for a device to which access may not be possible for the 25-year plus lifetime of a well or pipeline,” said Strong. “The interrogator, or complex optoelectronic/computer equipment normally deployed in a control room or in a protective enclosure, has a significantly greater probability of failure but is easily accessed and hence repaired or replaced.”

A number of different types of optical fiber sensors exist. In the past decade, sensors such as distributed temperature sensors suffered from calibration drift that result in somewhat less precise measurement of optical intensity. However, recent advances in interrogator, fiber and cable design have reduced these errors dramatically, Strong said.

“The trade-off in functionality between the fully-distributed nature of DTS versus the fewer, discrete measurement points of a Fiber Bragg Gratings-based system mean that operators are quite often happy to accept a reduction in absolute precision to gain the complete coverage of a distributed temperature sensor,” said Strong. “The most appropriate solution depends strongly on the specifics of the application.”

In pipeline leak detection applications, DTS is used to detect and locate the localized temperature changes caused by a leak. DAS can perform the same function, detecting initially a leak’s acoustic signal – especially with high-pressure gas leaks – and the changes in localized temperature.

“The combination of two different sensor methodologies (DTS and DAS) in a single cable is particularly powerful,” said Strong. “If both measurement systems report a leak then there is a greatly reduced probability of a false alarm.”

Early limitations of fiber optic technology include its inability to withstand high pressure, high-temperature hostile environments; the ability to access the fiber through the wellhead; and fiber darkening, in which fibers would literally go dark, meaning less light was returned from the fiber over time, eventually making them unusable, said Hill. The development of more resilient types of fiber has addressed fiber darkening and expanded the projected lifespan of fiber optics in the wellbore.

Advances in fiber optic technology that will ensure their survival in the high-pressure, high-temperature environments of wellbores have allowed the market for fiber optics in oil and gas to take off.

“Technology has gotten to the point where all the major barriers to entry have been overcome,” said Hill.

This has led to a resurgence in DTS capability, and significant interest by the oil and gas industry in DAS.

Will the decline in oil prices impact interest in fiber optics? There is an initial period where every budget will be slashed as people try to save money, said Hill. But he believes that oil prices could actually be beneficial for the wider production of this technology in the industry.

“We believe that if you can monitor it, you can manage,” Hill said of the technology’s ability to enhance production and efficiency.

VisionGain had estimated that expenditures for distributed fiber optic sensors by the global oil and gas industry will be $341.2 million in 2014. Spending for distributed fiber optic spending (DFOS) would not likely be as affected by lower oil prices as other areas due to its present reliance on midstream infrastructure and thermal enhanced oil recovery prices, said Grant Rudgley, senior energy analyst and consultant with research firm VisionGain, in a statement to Rigzone. Instead, the most at-risk areas for spending cutbacks on fiber optics is for future seismic application, which is likely to be overlooked in a commercially risk-adverse environment.

"However, better understanding of what impacts shale oil and gas production is of even more interest in a tighter margin environment," said Rudgley. "If DFOS leads to actions that lead to demonstrable results, then yes. Proving it – and removing the 'if' – is of more importance today, but at the same time, there is more interest in finding that edge today than there was a year ago."

Another fiber optic application at risk of spending cutbacks is in-situ oil sands development in North America.

"We are looking at less spending now and next year than there has been (around 50 percent less than 2014) on such developments," Rudgley commented.

He noted three brackets of investment in this area: those already committed to project under construction, those taking the long view, and those delaying.

"The delay of many projects means that capital expenditure will fall and DFOS will lose some of the potential market that we thought would have existed in the near-term."

Rudgley said that VisionGain sees greater potential for the use of DFOS onshore, where the overwhelming majority of applications are.

Since 2009, DAS has been the exciting growth area within the oil and gas industry. Pipeline monitoring has been the primary factor driving that interest. However, VisionGain has concerns that saturation of this market space may occur in the coming years, given the dwindling length of major pipelines in secure spaces that are perceived to need monitoring.

"This is why reservoir monitoring and seismic application DFOS case studies are very much worth keeping an eye on."

Fiber optics definitely offers the "best bang for the buck" for transporting more data longer distances, said Chirag Rathi, principal consultant with Frost & Sullivan's energy practice. As with other technologies, the oil and gas industry has a learning curve when changing to a new technology. But with the right amount of protection, cladding and protocols, Rathi sees fiber optic technology as a suitable candidate moving forward for the transmission of data.