Oil companies turning to submarine technology in fracking

USS Wyoming
REBECCA REBARICH/U.S. NAVY

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HOUSTON — A gossamer-thin glass line threaded two miles underground is allowing oilfield engineers to listen to a new kind of music: the sounds of fracking.

Halliburton Co. and competing providers of drilling gear are adapting acoustic spy technology used by U.S. submarines to record sounds made deep in the earth that can guide engineers in finishing a well and predicting how much oil will flow.

The ability to hear inside a well enables producers to fine-tune hydraulic fracturing, or fracking, the process that blasts underground rock with water, sand and chemicals to free trapped oil and natural gas. The technology is targeted at an estimated $31 billion that will be spent this year on fracking stages that yield less-than-optimal results, a majority of the work at 26,100 U.S. wells set to be pressure-pumped in 2013, according to PacWest Consulting Partners.

"We're creating a new science," said Magnus McEwen-King, managing director for OptaSense, a Qinetiq Group lc unit that's one of the fiber-optics pioneers for the energy industry. "From an acoustic perspective, this is very much the start of what I think is going to be a revolutionary technology."

Fracking has helped U.S. oil production reach a 21-year high. Environmental groups have criticized the practice because of concerns it may affect drinking water supplies.

Energy companies are fueling the booming business of so- called distributed fiber-optic lines, where the cord itself is a sensor for sound and temperature throughout its entire length.

The U.S. market for such lines, used across industries from energy to military, will almost double to $1.1 billion by 2016 from an estimated $586 million this year, according to a study published by Information Gatekeepers and revised this month by Light Wave Venture, which helps develop new companies using fiber-optic technology.

The prospect of fine-tuning energy discovery has the world's largest oilfield service providers joining companies with ties to the defense industry including OptaSense and U.S. Seismic Systems Inc., a unit of Acorn Energy Inc., to develop ways to eavesdrop on wells. Royal Dutch Shell, Chevron and Statoil are among customers testing the technology.

"This market is evolving very, very aggressively," said Dave Krohn, a Connecticut-based materials engineer who wrote the market study. "Clearly the driver is oil and gas."

Halliburton, the world's largest provider of fracking services, is working on cataloging the combination of sounds that signal the perfect frack: an explosion, cracking rock, and eventually the gurgle of hydrocarbons seeping into the well bore, said Glenn McColpin, director of reservoir monitoring at Halliburton's Houston-based Pinnacle unit. A bad frack means the rock didn't crack as much as it could have.

When perfected, a computer will convert the sounds to a graph that will show how deeply and thoroughly cracks penetrate the rock surrounding the well, indicating the success of each frack stage. The longer and more numerous the cracks, the more oil and gas will flow.

One fracking stage can cost about $100,000 and a typical well now will have about 15 stages, said Alex Robart, principal at PacWest. The effectiveness of each stage varies wildly. The industry generally subscribes to the 80-20 rule, meaning 80 percent of North American production comes from about 20 percent of the fracking stages, he said.

Finding out immediately which fracks were successful allows a company to repeat the process to improve flow.

"Our whole goal is to make the perfect frack every time," McColpin said. "You're spending millions of dollars pumping millions of gallons of fluid, and if you're only getting a third of the rock, you're getting a third of the production."

A fiber optic line consists of a stainless steel cable encasing one long, thin string of glass that vibrates when struck by sound waves. The sound waves are converted to light pulses reflected through the line, then converted by computer software back into sound that McColpin can monitor from his laptop.

"Bink, bank, boink" is what McColpin hears as a small metal ball rolls down the well bore and lands in a "ball seat" that triggers the rock's first fracture. The fiber line captures the noise of the ball and the reverberating blast of the perforation gun firing into the rock. Computer software converts those sounds into a colored graph on his laptop screen, etching a bright red fever line across a green background.

"Our whole goal is to make the earth transparent," McColpin said. "Now we've got a window into the well to see exactly what's happening."

The oil industry started experimenting with fiber optic lines' temperature-sensing abilities about a decade ago, and five years later started testing it with sounds.

In August 2009 OptaSense traveled to Alberta, Canada, to show off its acoustic fiber-optic line to Shell. Executives from both companies piled into an observation truck parked near the well site to oversee a fracking job while OptaSense's McEwen- King sat in his office back in England monitoring the real-time results on his computer.

As the perforation gun exploded, sound waves traveling along the fiber optic line were transformed into data that lit up his screen with a brightly colored graph illustrating the results.

"You guys just turned the lights on down there!" McEwen- King told his colleagues back in Canada. "The whole well-bore imaged instantaneously," he recalled in an interview earlier this month. Three years later, OptaSense announced an agreement with Shell to provide global frack-monitoring services using the acoustic lines.

Some of the world's largest oil producers are interested in the still-evolving technology, Joseph Elkhoury, general manager of microseismic services at Schlumberger.

"There's always this wide enthusiasm around a new technology," he said. Inevitably, that's followed months or years later by a drop in the adoption curve as customers realize the technology isn't everything they hoped it would be. Once the service companies fix some of the challenges, adoption picks up again, he said.

"We are in the wide-enthusiasm phase of acoustic sensing," Elkhoury said.

One of the biggest challenges for acoustic fiber in the oilfield is making the business case to use it onshore, Robart said. Installing the technology can cost as much as several hundred thousand dollars a well, meaning it doesn't pay off as easily on a $6 million land well as it would on a $50 million offshore well, he said.

To confirm how large a fracture was and where it went, companies still need to use a network of specific sensors called geophones to listen from a nearby monitoring well, measuring subtle earth movements from the rock cracking. Some service companies want to one day ditch these microseismic tools and get the same listening sensitivity from their one fiber optic line, helping bring costs down and becoming more efficient.

U.S. Seismic is using three acoustic fiber-optic lines to listen for sounds in place of traditional geophones. The technology provides a more accurate sense of how far the cracks penetrated the rock and in which direction, said Jim Andersen, chief executive officer of U.S. Seismic.

Contractors ranging from Halliburton to Exiius have begun permanently installing fiber optic lines in U.S. wells. During completion of a just-drilled well, the fiber can listen for subtle noises that suggest sealing the well with cement didn't work properly.

Then the fiber can listen for good and bad fracking stages, and finally it'll be able to confirm if oil and gas is flowing. Eventually they'll be able to actually measure production flow based on sounds, McColpin said. He compares it to a flute: as different holes in the well's casing are open or clogged, the sound pitch of fluids flowing through the well are affected.

Programmers also are working on algorithms to detect the difference in sound for water versus oil flowing into the well from surrounding rock. Then valves for different areas in the well bore could be opened or closed as needed to minimize water incursion, which is a waste.

Scientists also want to beef up the listening capability of the fiber optic line during seismic shoots of the underground rock to capture better reservoir images for future exploration.

Submarines were among the first adopters of acoustic fiber- optic technology in the late 1990s. Some of OptaSense's technology expertise originates from its parent company, Qinetiq, a British defense contractor providing military services ranging from drones to cyber security.

Before moving to U.S. Seismic, Andersen previously ran the group at Litton Industries Inc. that sold about $450 million worth of fiber-optic sensor technology to the U.S. Navy. Northrop Grumman Corp., a maker of surveillance drones, bought Litton in 2001 for about $5 billion.

Outside of oil and gas production, fiber optic lines are being used on pipelines to detect leaks or foul play, for monitoring perimeter security along a property fence line and to measure the stress on infrastructure such as roads and bridges. The rebuilt Interstate 35 bridge in Minneapolis is now packed with 300 fiber-optic sensors after it collapsed in 2007, Krohn said.

One of the biggest challenges for the new technology is figuring out what to do with the mountains of data they're collecting. Halliburton has assembled engineers, scientists and former U.S. space program technicians in a Houston lab to comb through data that pores in fast enough to fill up a DVD every 28 seconds.

So far, companies are afraid to throw anything out, not knowing what might prove to be the crucial puzzle piece later, McColpin said.

"It's untenable," he said. "You can't collect 15 terrabytes a week continuously for 20 years on a well."