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Specialty Optical Fiber Senses Temperature, Improves Oil and Gas Production

Extracting oil and gas is not as simple as drilling a well and sitting back to watch them flow out of the ground. Today's petroleum engineers rely on sophisticated "downhole" measurement technology to optimize production. [SensorTran](#), an Austin, Texas-based developer of advanced fiber optic sensors, is at the forefront of providing engineers with detailed temperature profiles anywhere within a well – even thousands of meters underground.



Temperature can tell engineers a great deal about what's happening underground, including the flow of oil and gas, reservoir analysis, and other conditions. "In producing wells the main thing oil and gas companies are trying to do is maximize flow out of oil or gas reservoirs. They will do certain things to improve the flow, such as pump water or chemicals into the well or inject steam," explains Dave Hickey, SensorTran Chief Operating Officer. "There can also be multiple zones in a single well and the reservoir engineers want to know which zones are producing better than others," he adds.

Traditional temperature sensing involves taking a measurement at a single location, usually with an electronic device or single-point fiber optics. "Instead of single-point measurements, SensorTran is able to take measurements at one-meter

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intervals anywhere in the well with a resolution down to .05°C," says Hickey. To do this SensorTran's DTS5100 Distributed Temperature Sensing (DTS) technology measures temperature over the entire length of the installed fiber and records temperature at every location.

DTS is based on optical time-domain reflectometry (OTDR) and uses optical fiber instead of electronic sensors. When laser pulses are sent through the fiber, light is backscattered as the pulse propagates down. Since the velocity of light propagation in the optical fiber is known, distance can be determined. And, because some of the backscattered light is affected by temperature, it is possible to determine the precise temperature at specific points along the entire length of the fiber.



Some DTS applications, such as monitoring underground power lines, are possible using standard telecommunications optical fiber. "But the downhole environment of an oil or gas well requires specialized fiber," says Vic Swenson, a Optical Systems Engineer with SensorTran.

SensorTran turns to OFS Specialty Photonics to provide engineered fiber solutions. "Their long history and heritage – and their ability to assess customer applications – are invaluable," notes Swenson.

Solutions for a harsh environment

Standard optical fiber is not suitable for the harsh downhole environment. Pressures within wells average less than 10,000 psi but can reach as high 30,000 psi, and temperatures as high as 200°C are not uncommon. In addition, shock and vibration that can damage an electronic gauge have no impact on optical fiber.



"Fiber has a significant advantage over electronics because you're not putting sensitive equipment in this very rough environment. With a DTS system, all the electronics are on the surface, not down in the well," says Hickey.

Another issue with the downhole environment is the effect of ever-present hydrogen on the fiber. When hydrogen penetrates the glass it causes a condition known as

"hydrogen darkening" which results in increased attenuation that in turn affects the accuracy of temperature readings.

OFS has developed hydrogen-resistant graded-index optical fibers that are optimized for DTS applications. The fiber core and cladding are silica glass drawn from preforms made with extraordinary process control. Dopant chemicals minimize the sensitivity of the fiber to hydrogen-induced loss.

In addition, OFS has pioneered specialized coatings that also minimize the impact of hydrogen. One coating consists of a very thin layer of carbon that chemically bonds with the glass to provide a hermetic seal against moisture at all temperatures. Carbon dramatically extends the lifetime of the fiber and provides a barrier against

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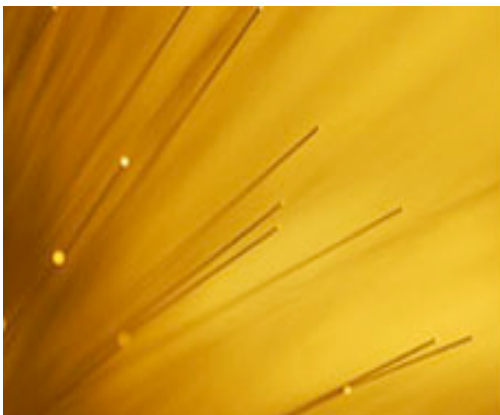
hydrogen ingress at temperatures up to 130°C. A coating of PYROCOAT® polyimide, a high-temperature material, allows the fiber to perform in environments ranging up to 300°C.

Improving overall performance

According to Swenson, "OFS is able to do something that has been historically very difficult to do – that is, provide long lengths (up to 8 kilometers or more) of coated graded-index multimode fiber. They have also been able to apply the coatings in such a manner that the strain caused by the coating is minimized and uniform along the entire length of the fiber. This is important to a DTS application because a uniform distributed attenuation of the light propagating down the fiber is preferred."

In addition to coating technology and hydrogen-resistant glass, Swenson credits OFS with other advances. "For example, they've made tremendous progress in minimizing the bend radius where attenuation effects start to occur. It is not an insignificant thing what they've done on some very basic fiber issues," he adds.

Optimizing oil and gas production gets more complicated all the time – and the financial risks are tremendous. As a result, OFS and SensorTran continue to work together on enhancing fiber-based sensing technology that makes wells more efficient and productive. Says Swenson, "OFS has a long history in fiber optics and specializing in customer solutions that need specialty fiber and cable. They're right at the forefront of very difficult fiber-based solutions."



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