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Dual Laser Scheme Revolutionizes DTS Deployments

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Abstract

Distributed Temperature Sensing (DTS) systems have offered oil and gas companies critical asset monitoring solutions for years. DTS monitoring solutions provide real-time, dynamic temperature data with high accuracy, fine resolution and fast measurement speeds. DTS systems can provide tens of thousands of discrete temperature measurement readings along the complete length of an optical sensing fiber. These systems provide significant cost savings by identifying the location of leaks, optimizing gas lift operations, identifying under-performing zones, and monitoring thermal changes in steam drive applications. This paper discloses the first truly self-correcting DTS solution, which incorporates a revolutionary dual laser technology. This technology provides energy companies with the simplest, fastest, and most reliable DTS deployment available to the industry, combined with a capability to automatically correct for dynamic changes to the sensing fiber.

Introduction

The use of fiber optic sensors in the oil & gas industry is well known, with several hundred installations worldwide. Fiber optic sensors have been used in various applications for measurement of important factors such as temperature, pressure, strain, flow, and seismic signals. Fiber optics have been installed into a wide variety of oil wells over the last 25 years [Kragas, Williams, Meyers; 2001], with deployments spanning from offshore wells to shallow, low cost land wells [Jaaskelainen; 2006]. In addition, fiber optic sensing solutions are moving into new and exciting applications such as Real Time Casing Monitoring [Rambow, Dria, Childers, Appel, Freeman, Shuck, Poland, Dominique; 2007], where fiber optics are used to monitor down hole casing deformation, or Real Time Completion Monitoring [Bakulin, Sidorov, Kashtan, Jaaskelainen; 2008], where acoustic waves are experimentally investigated for monitoring changes in sand screen completions.

Distributed Temperature Sensing (DTS) systems based on Raman backscattering in optical fibers are the type of fiber optic sensing that are most commonly deployed. DTS systems are used in a large variety of applications, including completion monitoring, gas lift monitoring, flow assurance / flow modeling, thermal hydrocarbon recovery operations, and oil/gas/LNG pipeline monitoring, covering temperatures ranging from -196°C to +300°C and covering pressures up to 30,000 psi. A thorough understanding of the applications, deployment methods, down-hole conditions, and the optical system itself is required for a successful system implementation. In the past, limitations of available fiber optic sensing cables have negatively impacted the accuracy, resolution, and useful lifetime of installed systems due to Hydrogen darkening in optical fibers [Smithpeter, Normann, Krumhansl, Benoit, Thompson; 1999]. However, recent advances have resulted in successful implementation of DTS systems in harsh environments like thermally-assisted hydrocarbon recovery operations [Kaura, Sierra; 2008].

Even with all the great advances in technology and materials, proper installation has often required the presence of one or several optical expert(s) to install, calibrate, and start-up the system. Time varying effects, like hydrogen darkening in optical fibers, have frequently been addressed by installing double ended systems to allow for limited temperature correction [Smithpeter, Normann, Krumhansl, Benoit, Thompson; 1999, & Smolen, Spek; 2003]. However, double ended systems require twice the optical fiber (as compared with single ended systems) and use DTS systems with twice the reach, which drives the cost upward for the end user [Smolen, Spek; 2003]. In addition, double ended DTS systems experience increased noise in the temperature trace and therefore require increased measurement time. This paper reviews the latest advance in Active Plug & Play DTS technology, where

Initial data from the single wavelength system shows temperature calculation errors among the different fibers (Fig. 4a) due to differential attenuation. The temperature data for probes 1-3 can be corrected to some extent by manually varying the differential attenuation factor, but the data for probe 4 is non-linear and cannot be corrected using conventional technology.

The temperature traces measured by the dual laser auto-correcting system show correct temperature profiles (see Figure 4b) for all fibers, even the non-linear, hydrogen-darkened fiber. This example clearly illustrates the revolutionary capabilities of the new patent-pending dual-wavelength technology.

Conclusions

A new dual wavelength DTS system immune to dynamic fiber changes like Hydrogen-induced darkening has been introduced. The theory shows how the dual wavelength DTS system operates and how wavelength, distance, and time-dependent differential attenuation issues can be corrected. The theory is then experimentally verified on 4 fibers with different properties. The most impressive result can be seen on the Hydrogen-damaged fiber which was recovered from the field, where the differential attenuation factor shows severe non-uniform degradation over distance. The dual wavelength technology will enable faster and more economic deployment of DTS systems, while providing a unique capability to correct for dynamic changes to any fiber optic sensing cables in Hydrogen-rich environments, such as Steam Assisted Gravity Drainage (SAGD).

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