Comparison of Raman, Brillouin, and Rayleigh Distributed Temperature Measurements in High-Rate Wells

Paper Ref : SPWLA-2022-0011

Authors : Brian C. Seabrook, ExxonMobil Upstream Research Co.; Andreas Ellmauther, Michael LeBlanc, Mikko Jaaskelainen, John L. Maida, Glenn A. Wilson, Halliburton

Speaker : Brian C. Seabrook

Abstract:

With the maturity of and demand for fiber optic sensing technology growing steadily over the last few years across multiple basins, operators are seeking fiber optic sensing solutions that address the technology challenges associated with life-of-field monitoring of subsea developments. Single-ended distributed temperature sensing (DTS) are typically acquired using Raman optical time-domain reflectometry (OTDR) on multi-mode fiber. However, for topside interrogation of subsea completions, Raman DTS performs poorly due to the available optical power budget, and the wavelength dependency of the measured Stokes and anti-Stokes intensities, as the temperature profile is calculated as a function of the ratios of these signals. The optical attenuation across connectors and splices may, in many instances, have a wavelength dependence that varies with temperature and/or directionality of the propagation of the optical signals. Any wavelength dependent attenuation as the signals pass through connectors, splices and optical feedthrough systems will generate step changes in the measured temperature profile. Brillouin OTDR can provide a DTS alternative that overcomes these challenges and operates on single mode fiber.

Brillouin OTDR operates with a large dynamic range to measure a wavelength (frequency) shift of the Stokes/anti-Stokes components that is proportional to both strain and temperature. Since downhole cables are manufactured with optical fibers suspended in a gel and with appropriate extra fiber length (EFL), any fiber strain relaxes, and the Brillouin wavelength shift is an absolute temperature measurement. We typically associate coherent Rayleigh OTDR with distributed acoustic sensing (DAS) on single-mode fibers, but low frequencies also contain a relative temperature dependence.

In this paper, we report on a comparison of Raman, Brillouin, and Rayleigh DTS simultaneously acquired in the same high-rate producer and injector wells. We validate that, with appropriate cable design, Brillouin DTS can be simultaneously operated on the same single-mode fiber with DAS and can deliver absolute temperature measurements suitable for production analysis. We conclude with a discussion about the implementation of this DAS-DTS solution for sensing subsea completions.

Bio:

Brian C. Seabrook is a Wells Research Engineer at ExxonMobil Upstream Research Company. His research is focused on fiber optic sensing and building workflows to utilize the sensor data for surveillance and optimization of wells and associated facilities. He has over 20 years of industry experience, is a licensed Professional Engineer in the state of Texas, USA, and earned his PhD in civil and environmental engineering from Duke University in 2001.