2009 North American Technology Innovation Award

OZ Optics Limited

The 2009 Frost & Sullivan North American Technology Innovation Award in the field of fiber-optics based structural health monitoring systems goes to OZ Optics Limited in recognition of its development of the Foresight™, a long range structural health monitoring system. Foresight™ represents a breakthrough innovation in the field of range, sensitivity, and availability as it is easily applicable across almost all pipelines and energy transmission systems. The monitoring system uses the phenomenon of Brillouin scattering for sensing and is distinguished with high performance capabilities when compared with, Raman scattering-based or fiber Bragg grating-based fiber-optics monitoring technologies. Particularly, it offers separate temperature and strain measurement as well as higher spatial resolution, speed and measurement accuracy.

Company Background

OZ Optics Limited, based in Ottawa, Canada, was founded by current president and CEO, Ömür Sezerman, in 1985 and the technologies offered by the company are derived from the research activities conducted by their founder. OZ Optics designs, manufactures, and markets fiber optic components for existing and next-generation optical networks and systems based on proprietary technology and patents. Their products enable customers to develop optical networking systems that transmit data reliably at increasing data rates. The company also designs and manufactures handheld test and measurement equipment for the fiber optic market. The company's state-of-the-art design capabilities enable the rapid development of a broad range of high-quality products to meet customer specifications and requirements. Among their customers are companies from a broad spectrum of sectors such as telecommunications, cable television, medical, military, industrial, and educational domains.

Overview and Key Challenges

The structural health monitoring (SHM) concept appeared in the 1990s as a method that enables efficient maintenance and increases the safety of large engineering structures. The real-time, "in situ" monitoring of structures emerged as a result of technology advances in fields such as electronics, sensors, telecommunications, and software. SHM systems are being developed in order to provide continuous real-time information about threats related to condition of major constructions. The significance is usually evaluated by the realization of benefits in maintenance cost savings, safety, or a combination of both. Hence, SHM systems find applications mostly in civil engineering, aerospace, energy generation, and transportation systems. Current applications include bridges and dams, aircraft wings, pipelines, and energy generation turbines.

Ultrasonic and fiber optic sensors are perhaps the most widely used for SHM. The ultrasonic approach is based mainly on acoustic emission, since there is often an ultrasonic wave created when internal material strains are released in the form of a flaw. Therefore, distributed piezoelectric-based sensor networks are often employed in this technique. One of the current trends in this area is using energy harvesting capabilities to enable wireless sensor communication.

Optical fibers are useful for SHM since they are very sensitive to external conditions, widely applied in telecommunications, easily available, and they provide both communication and sensing capabilities. Using laser light as an information carrier gives it rapid, reliable, and accurate feedback. Fiber optic sensors use phenomena such as deflection, diffraction, and the scattering of laser light. Most often they occur when an optical fiber is subjected to a mechanical strain or temperature changes. Optical SHM benefits to a great extent from compact laser designs, such as laser diodes, which made fiber-based measurement systems more portable and essentially smaller. Due to the above reasons, they are suitable for employment on aircrafts.

Areas of intensive development in fiber optic-based SHM include the measurement range, separation of detected quantities, increasing the number of parameters evaluated, and decreasing the cost of implementation and usage. There are a few approaches in optical fiber SHM systems which are based on fiber Bragg gratings, Raman scattering, and Brillouin scattering.

Foresight™, which is based on Brillouin scattering, is capable of a 0.1με strain resolution or 0.005 degrees C temperature resolution, which makes it a leading solution in the field of fiber optic-based SHM techniques. It has also certain advantages over acoustic emission techniques. The device does not require any additional electric connections to acquire the signal and it provides temperature measurement which is impossible with acoustic sensors.

Technology Description

Foresight™ is a series of fiber optic distributed strain and temperature sensors (DSTS). They use Brillouin scattering in optical fibers to measure changes in strain and temperature along a fiber. Brillouin scattering occurs when a light that propagates in a medium encounters a time dependent density variation. When laser light propagates in an optical fiber and hits a density change it slightly changes its frequency, this is called the Brillouin shift, and is scattered usually in the opposite direction to the input beam.

The OZ Optics DSTS system consists of two laser sources that direct light in opposite directions in the same fiber. One of the lasers operates in a continuous wave mode and the other in a pulsed mode. They work on different frequencies, and when the difference is equal to the "Brillouin frequency" of the fiber, a strong interaction between beams occurs (coherent amplification phenomenon) and enhanced acoustic waves are generated in the fiber. In this way the weak Brillouin signal is amplified and can be easily detected and localized by optical time domain relfectometry type of equipment. The Brillouin frequency changes linearly with the strain and temperature exerted. Therefore, the continuous laser is a tunable device, which enables frequency scanning.

The above principles describe Brillouin Optical Time Domain Analysis (BOTDA) technique. OZ Optics provides high performance for such a setup proven by unique spatial resolution, measurement accuracy, and speed. However, BOTDS needs access to both edges of the fiber. Therefore, Foresight™ also has Brillouin Optical Time Domain Reflectometer (BOTDR) capability, which is another distinguishing feature. When compared to the BOTDA technique, there is no occurrence of coherent amplification in BOTDR, and therefore the scattered signal is weaker and the measurement range is decreased. Nonetheless, the BOTDR is an additional function of the system and it allows making measurements if the fiber is broken or if there is an access to only one side of the fiber.

Technology Implementation

The Foresight™ DSTS system is commercially available and its outstanding properties, such as long measurement range, measurement spatial resolution, and accuracy, as well as two working modes, distinguish it from other solutions. It can work on standard telecom single mode fiber, while Raman-based systems require multimode type. It does not require calibration after set up and can cover of up to 50 km distance, compared to 20 km of Raman SHM solution. On 20 km distance it responds in only two seconds and is based on frequency changes, hence it is not sensitive to attenuation. It measures temperature and strain separately, without any additional compensation module, and enables spatial resolution as short as 0.1 m and temperature resolution down to 0.005°C. Foresight™ also offers a broad working temperature range of 270°C to +800°C, depending on cable material. Such capabilities position OZ Optics as a technology leader in the field of fiber optics-based SHM.

Best Practices

Cutting edge research and development is one of the company's on-going corporate strategic goals. The primary research on Brillouin sensors was conducted by the scientists from the University of Ottawa, Canada. OZ Optics continued the project, performing additional research which led to product development and commercialization. The company has applied for patents with regards to Foresight™ (US Patent Applications 20070047875 - Remote monitoring of optical fibers, 20070103670 - Fault detection in optical fibers) and has collaborated with other universities and companies in the development of the product. Other research achievements are also covered by patents. There are US patents, such as "Stress relief in fiber optic arrays" (patent number 7,058,275), "Light source control system" (patent number 7,067,993), "Microstructuring optical wave guide devices with femtosecond optical pulses" (patent number 7,095,931), and "Adjustable focus connector with spring action" (patent number 7,431,513).

Conclusion

OZ Optics has successfully developed and commercialized its fiber optic-based structural health monitoring system called Foresight™ DSTS whose outstanding features, such as the measurement range, the dual technique capability, high spatial and temperature resolution, and sensitivity, gives the company a competitive advantage over the rest of the market. In recognition of its achievements in developing and commercializing an innovative fiber optic-based structural health monitoring system, OZ Optics is presented with the 2009 North American Frost & Sullivan Technology Innovation Award.

Award Description

Frost & Sullivan's Technology Innovation Award is bestowed upon a company (or individual) that has carried out new research, which has resulted in innovation(s) that have or are expected to bring significant contributions to the industry in terms of adoption, change, and competitive posture. This award recognizes the quality and depth of a company's research and development program as well as the vision and risk-taking that enabled it to undertake such an endeavor.

Research Methodology

To choose the award recipient, Frost & Sullivan's analyst team tracks innovation in key hi-tech markets. The selection process includes primary participant interviews and extensive primary and secondary research via the bottom-up approach. The analyst team shortlists candidates based on a set of qualitative and quantitative measurements. The analysts also consider the pace of research and technology innovation, and the significance or potential relevance of the innovation to the overall industry. The ultimate award recipient is chosen after a thorough evaluation of this research.

Measurement Criteria

In addition to the methodology described above, there are specific criteria used to determine the final rankings. The recipient of this award has excelled based on one or more of the following criteria:

- Significance of the innovation(s) in the industry, and across industries (if applicable).
- Potential of the products of innovation(s) to become industry standard(s).
- Competitive advantage of innovation vis-à-vis other related innovations.
- Impact (or potential impact) of innovation(s) on company or industry mind share and/or company bottom line.
- Breadth of intellectual property related to the innovation(s), that is, patents, scientific publications, and papers in peer-reviewed journals.

About Best Practices

Frost & Sullivan Best Practices Awards recognize companies in a variety of regional and global markets for demonstrating outstanding achievement and superior performance in areas such as leadership, technological innovation, customer service, and strategic product development. Industry analysts compare market participants and measure performance through in-depth interviews, analysis, and extensive secondary research in order to identify best practices in the industry.

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