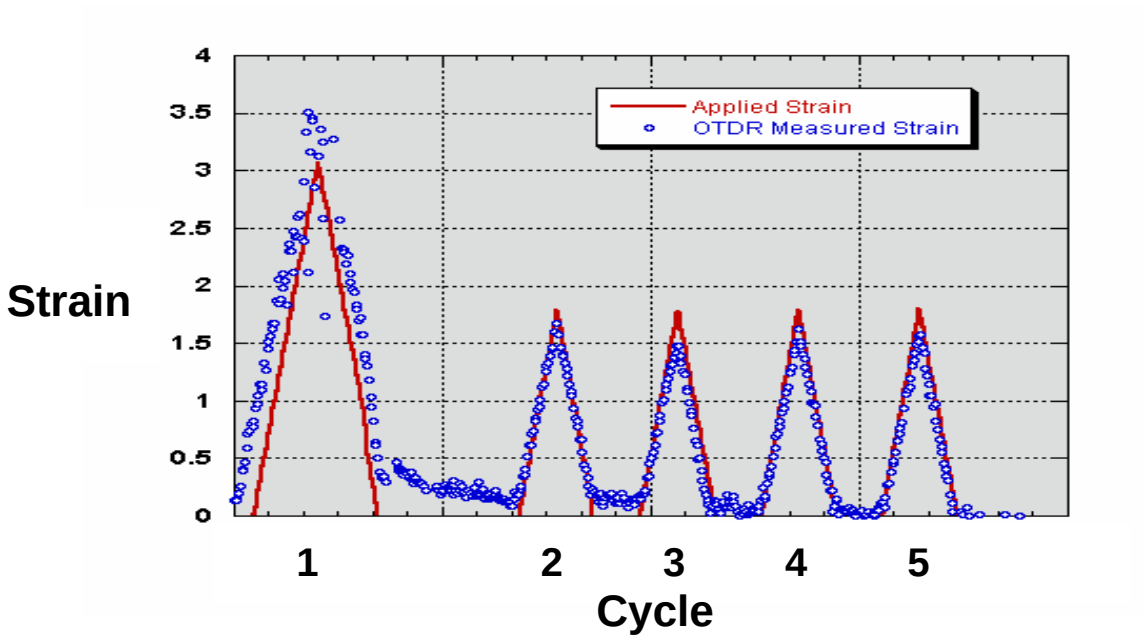
Plastic Optical Fiber Shows Promise to Monitor Strain in Offshore Platform Mooring Ropes

Synthetic fiber mooring rope is emerging as an important economically enabling technology for mooring drilling and production platforms in deepwater. Used initially in Brazil, polyester mooring ropes are now being deployed in the Gulf of Mexico. Environmental conditions associated with hurricanes and loop current are more severe in the GOM and complicated inspection procedures are being required by the Minerals Management Service to insure reliability. Current procedures involve inserting short test sections in the upper portion of the mooring rope with periodic retrieval for ultimate strength testing. The procedure is expensive as well as introduces certain operational risks. An alternative inspection procedure is being developed by the Oak Ridge National Laboratory, Shell Global Solutions U.S., Whitehill Manufacturing Corp. and Puget Sound Rope Company. The procedure is based on *in situ* measurement of the characteristically large axial strain in the mooring rope. The new technology involves using a high strain plastic optical fiber and an optical time domain reflectrometry (OTDR) technique to measure the strain based on the time required for a beam of light to traverse the optical fiber to a reflective interface and return.

The application of plastic optical fibers is being investigated because mooring ropes experience strains of several percent far exceeding the capability of glass fibers. Several plastic optical fibers have been studied including PMMA and perfluorocarbon. A perfluorocarbon fiber was found to have the lowest attenuation (loss of signal) for the wavelength of light studied. Although attenuation is higher for plastic optical fibers than for glass optical fibers; it is expected that the strain in ropes on the order of 1000 meters long can be measured with longer lengths expected to be possible with advanced technology being studied.

Results of laboratory tests comparing the applied strain in a small rope element with the strain measured using an embedded plastic optical fiber for the first five cycles of loading is presented in the graph below. Loading was applied in a stroke control mode and the maximum strain was approximately three percent rain in the first cycle, but reduced to approximately 1.8 percent in subsequent cycles due to termination seating and relaxation of the polyester. Good correlation is recorded between the applied strain and the strain measured using the plastic optical fiber and OTDR technique. It is also encouraging for the application to observe that the plastic optical fiber did not take a permanent set or brake during cyclic loading.

A combination of a special braided rope carrier designed to locally restrain the optical fiber and placement of reflective interfaces at discrete locations along the length of the optical fiber is currently being studied for the purpose of detecting strain anomalies such as caused by local rope damage. Future plans include conducting tests on larger and longer ropes representative of mooring ropes proposed for offshore service and refinement of the technique and instrumentation for practical deployment of the technique offshore.



Ref: Smith, D. Barton, and Williams, Jerry G.: *Monitoring Axial Strain in Synthetic Fiber Mooring Ropes Using Polymeric Optical Fibers*. Offshore Mechanics and Arctic Engineering Conference, Cancun Mexico, Paper OMAE2003-37402, June 8-13, 2003.

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