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Present and Future Possibilities in Optical Condition Monitoring of Flexible Pipes

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Abstract

This paper describes the currently available optical condition monitoring options for flexible pipes used in the offshore industry. Temperature monitoring systems for the entire length of the pipe are widely commercially available, while point-based strain monitoring is a newer technology that is seeing increased field use. However, several upcoming fiberoptic technologies offer new possibilities within riser monitoring. Together with the existing sensing technologies, this will allow unprecedented insight into pipe operating conditions, which in turn will lead to more accurate models for operating conditions as well as far better estimates of the remaining pipe lifetime. Additionally, increased real-time monitoring can become a valuable tool for fault detection and predictive maintenance.

Introduction

Flexible pipes used in the offshore industry (especially those used in dynamic applications) are subject to extreme operating conditions due to high temperatures, high pressures, large tensile loads, a corrosive environment and constant motion. These conditions in turn put extreme demands on the material performance and design principles of the pipes, especially since most operators also want the pipe lifetime to be as long as possible, often 20 years and preferably more. Coupled with the fact that flexible pipes are very complex products consisting of many layers with interactions that are not yet completely understood and documented, the estimation of pipe behaviour and lifetime prediction can be a challenging exercise. This becomes especially true since designers often have to assume a worst-case scenario when it comes to the combination of different load cases.

All these factors make it desirable to monitor different loads (mechanical, chemical etc.) on the structural elements of a flexible pipe during operation, eg. to:

1. Improving the theoretical understanding of how the most important structural elements of the riser behave under differing load conditions, thus improving riser models and removing some conservatism from the design process. This aspect becomes more critical when moving to greater water depths, since the weight of a deepwater riser can become a limiting factor to its installation capability and service life performance.
2. Obtaining a more precise estimate of remaining riser lifetime based on knowledge of the actual load conditions the riser has been subjected to, rather than a set of design assumptions.
3. Obtaining an early warning system of potentially hazardous abnormal conditions.
4. Reducing the insurance premiums associated with the riser's oil production.

The primary parameters of interest to measure in the flexible pipe are strain and temperature levels, as these in particular influence the fatigue performance of the riser. Since fatigue of the tensile armour is often governing the riser lifetime, more precise knowledge of the stresses in the tensile armour has a high priority. Electrical wiring is highly undesirable in the explosion-risk environment of an oil platform, which means that optical fibers are one of the few practical means of real-time riser monitoring.

An Optical Monitoring System (OMS) is basically implemented by incorporating optical fibers into the riser armour layers or parts of its supporting structure, such as a bend stiffener or clamp-on devices. Systems that are mounted externally on a riser have previously been used, but it has the downside that actual load conditions, such as tensile layer fatigue stresses, have to