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Onboard Monitoring System of Overbend Pipe During Deepwater S-Lay Installation

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In S-lay operations, the pipeline passes over the stinger and is laid on the seabed after welding and nondestructive tests. The high combined loadings of axial tension, bending moment, roller reaction force, and the pipelay vessel motion may result in plastic deformation in the pipeline, which is difficult to accurately quantify. A real-time onboard monitoring system is recommended to guarantee the safety of the pipelaying process in challenging projects that include very large strain in the pipeline. However, most of the current onboard monitoring systems focus on the submerged section and sagbend section of the pipeline. The overbend section is ignored because of the uncertainty resulting from the combined loadings and the dynamic process during the pipe passing over the stinger. The present paper proposes a novel online monitoring method based on the roller reaction force measurement, which can monitor the dynamic overbend pipe strain fluctuations in real time. Relevant analytical equations in the model are first derived, then a large-scale hybrid model test and numerical simulation are carried out to verify the proposed monitoring system.

INTRODUCTION

Submarine pipelines are often laid onto the seabed by the S-lay method schematically illustrated in Fig. 1. The name "S-lay" comes from the configuration of the pipeline suspended between the pipelay vessel and the seabed. Compared to other pipelaying methods, such as J-lay, reel lay or tow lay, S-lay is known as highly cost effective. Short sections of the pipeline are welded onto the pipelaying vessel firing line to make a continuous pipeline. It then passes through the tensioner and slides over the curved stinger downward to the seabed (Palmer and King, 2004; Heerema, 2005). In the overbend section, the pipeline bends from horizontal to the stinger curvature and then leaves the stinger at a certain departure angle depending on the water depth and pipeline dimensions. Large deformation is induced under the combined loadings of bending, axial tension, roller reaction force, and the pipelay vessel motion (Xie et al., 2015). The strain of the overbend pipeline section is relatively large compared with that of the sagbend in deepwater operations, because of the great stinger curvature and strain intensification effects at the roller support location (Torselletti et al., 2006a; Torselletti et al., 2006b; Perinet and Frazer, 2008). As the pipelay operations move to areas with harsher conditions, the risks of the overbend pipe increase. Real-time monitoring of the pipelay operation would be an effective way to guarantee the safety of the operation. Økland et al. (2008) presented a system that utilized the position of the vessel and some tension measurement for the pipe, as well as the current conditions. That system could predict the pipe catenary geometry and installed position of the pipe with good accuracy. Taby et al. (2011) built an onboard monitoring system based on real-time data collection and a 3-D finite element analysis model that can be used to trace the touchdown point of the installation. However, in all existing analyses, only the pipe geometry configuration and touchdown zone at the sagbend section are monitored. On the contrary, the overbend pipe is not well considered.

The scope of this paper is to design a real-time onboard monitoring system for the overbend pipe during S-lay operation. In real projects, the dynamic roller force between the pipeline and the stinger roller can be measured by load cell; however, the pipeline strain is impossible to measure, because it keeps passing the stinger downward to the seabed. The core idea of the monitoring system is to measure the roller force first and then utilize the measured roller force to predict the real-time pipeline peak strain indirectly. To achieve this aim, the relation between the roller force and pipeline peak strain at roller location is first derived. Then a large-scale hybrid model test and finite element simulation are carried out to verify this monitoring system.

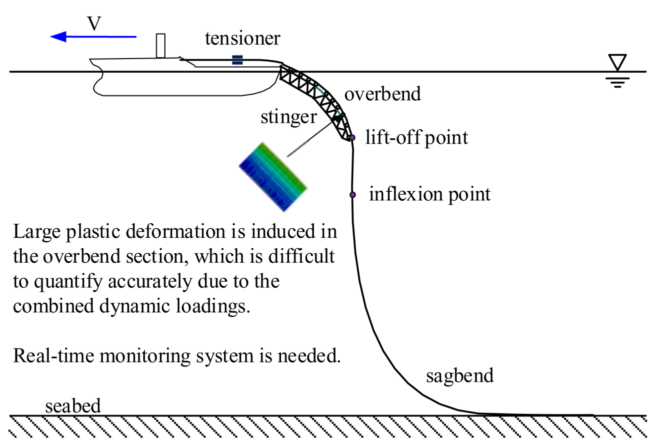

Fig. 1 S-lay operation

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