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3D Modeling Improves Deepwater Umbilical Design Dependability

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Abstract

Until recently, interactions between the internal components of an umbilical have been more or less neglected in modeling for fatigue prediction. In deeper waters, and with larger umbilicals, such interactions can contribute significantly to creating the conditions for umbilical failure. A new approach to deepwater umbilical design combines proven global systems models with more complex 3D models to capture local stresses and contact between internal components. This new approach to modeling umbilical behaviour goes beyond the traditional, cross-sectional analysis to encompass 3D lengths. From design through to operation, the 3D modeling approach gives clients a deeper understanding of umbilical performance and the technical risks they face. As a result, decision making about design and installation is more informed, even in highly challenging environments. This presentation discusses the process of 3D modeling, highlighting ground-breaking improvements on current designs. It cites successful pilot case studies, such as the recent verification of the F56 umbilical installed on the world's deepest producing field, where the need for accurate assessment of both strength and fatigue criteria was satisfied by the application of the 3D modeling capability. The presentation provides a compelling insight into a revolutionary new deepsea technology.

1. Introduction

Until recently, interactions between internal components of an umbilical have been more or less neglected in modeling for fatigue prediction. However, in deeper waters and larger umbilicals, such interactions can contribute to umbilical failure. Steel tube umbilicals (STUs) link a host/control platform to associated wells and provide the hydraulic, electrical, signal and chemical functionality required for each well. Failure of even a single component in an umbilical will generally halt production because well control or flow assurance requirement has been lost. Locating a failure presents significant challenges, and to repair a dynamic section is not feasible because of the high level of structural integrity required under the demanding conditions in which operation takes place. Therefore, the processes and techniques used to design STU systems for the maximum reliability and integrity need to resemble the actual behavior of the components as closely as possible.

To date, the relatively simple calculation used to analyze the behavior of umbilicals in shallower water has yielded acceptable results. However, as requirements shift towards deeper water and larger-diameter, heavier umbilicals, the interactions between the umbilical’s internal components contribute additional stress and fatigue. Using traditional methods of design in these circumstances can lead to a non-conservative design, increasing the possibility of umbilical failure.

A suite of tools and processes has been independently developed, which comprises advanced 3D umbilical modeling techniques for evaluating the internal performance of large umbilicals in deep water. These tools and processes allow the quantification of inter-component friction stresses as an integrated part of the current project-execution process.

2. Umbilical Fatigue Analysis Methodology

A methodology for fatigue life prediction of structures with helical reinforcements and components, such as umbilicals and flexible pipes, has been developed. Figure 1 shows the flow chart of the fatigue analysis procedure.