OTC 20256

Analytical Estimation of Pretension Requirement to Inner Pipe of Pipe-in-Pipe Flowline in Ultra Deep Water Using J-Lay Installation

Ranil Banneyake, Jason Sun, Paul Jukes, and Jack Chen, J P Kenny, Inc.

This paper was prepared for presentation at the 2009 Offshore Technology Conference held in Houston, Texas, USA, 4–7 May 2009.

Abstract

The pipe-in-pipe (PIP) offshore flowline is gaining popularities in ultra deep water developments due to its better characteristics in thermal insulation, thermal expansion, seabed stability, free span and maintenance. So far most of the larger size PIP flowline are installed using J-lay method. During the pipe welding and lowering process, the vessel tensioner grabs the outer pipe with the inner pipe free-standing inside the outer pipe. Therefore a large top lay tension is applied to the outer pipe while the inner pipe is under a sizable compression due to its own weight. A bulkhead is welded to the both inner and outer pipes with a predetermined spacing. As the PIP is being lowered toward the sea floor, the large lay tension on the outer pipe is gradually released, and the outer pipe tends to go back to its original length. This results in a push to the inner pipe from the outer pipe and develops a locked-in compression in the inner pipe and a locked-in tension in the outer pipe. In the ultra deep water PIP case, the locked-in loads and locked-in stresses could be critical if they are not well addressed.

The solution to limit the locked-in effects to the inner and outer pipes is to apply a predetermined pretension to the inner pipe before both the pipes are welded together through the bulkhead. The pretension is a function of water depth, pipe length, lay angle, bottom lay tension, soil friction, pipe wall thickness, content density, content temperature, content pressure and bulkhead spacing, installation sea state and vessel motion. The accurate prediction of the pretension demands significant resources and time through utilizing the advanced nonlinear finite element analysis (NLFEA) tools such as ABAQUS.

This paper proposes analytical formulations to estimate the pretension requirement to the inner pipe. The formulations are validated using ABAQUS modeling. The proposed formulations can be used as a cost effective alternative to the more time consuming and cost driven FEA method, especially when only a high level analysis is needed such as in the FEED stage or as a starting point for the detailed design stage.

Introduction

With the ever increasing demand for oil and gas and the fast depleting surface reservoirs, oil and gas companies are forced to search for new oil reservoirs, and hence the project requirements for pipeline systems are intensifying. Currently, subsea systems are being designed for water depths to 10,000 feet, high product temperatures and high pressures. Designing pipelines to transport high pressure and high temperature (HPHT) oil and gas from these deepwater locations is challenging. Pipe-in-pipe (PIP) flowlines are widely used to address this challenge because of their superior insulation capacity [Ref. 1, 2, and 3]. With PIP flowlines, the pipe carrying the hot oil or gas is placed inside another pipe; thermal insulation in the ring-shaped space between the two pipes minimizes blockages or hydrates that can form in the pipeline by providing an adequate thermal barrier to reduce heat loss [Ref. 1]. Further, PIP flowlines are gaining popularity due to their good characteristics in thermal expansion, seabed stability, free span and maintenance.

As of now, most of the larger size PIP flowline are installed using J-lay method. During the pipe welding and lowering process, the vessel tensioner grabs the outer pipe with the inner pipe free-standing inside the outer pipe. A large top lay tension is applied to the outer pipe while the inner pipe is under a sizable compression due to its own weight. When un-bonded, as-laid or lock-in compressive and tensile stresses on the inner pipe and the outer pipe, respectively, will result due to the obstruction of the stress relieve during the pipe lowering process by the friction between the two pipes. Bulkheads are welded to both the inner and outer pipes with a pre-determined spacing in order to isolate the sections of pipe in case of internal flooding. In this case, as the PIP is being lowered toward the sea floor, the large lay tension on the outer pipe is