

Lateral Buckling Performances of Untrenched HT PIP Systems

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ABSTRACT

PIP systems get increasingly application for HT medium transportation in offshore oil/gas industry, and for those directly laid on the seabed one of the primary service risks is lateral buckling. PIP systems are generally filled up with adiabatic materials in annular space, and the inner carrier pipe always suffers a high temperature load. The possible buckling deformations of inner and outer pipes are not synchronous, and the carrier pipe may buckle under some shorter wavelengths in the annular spaces. Depending on the PIP structures, the buckling deformations of carrier and casing pipes are interrelated because bulkheads, donut plates and spacers can all transfer lateral deformations. This paper aims at acquiring a more precise description on PIP system buckling process by using FE models. Two typical PIP structures are discussed in this paper. One can be called compliant systems which has a connection between the carrier pipe and the casing pipe at close intervals by donut plates. The connection can act as steel water-stops and allow the lateral displacement of the carrier pipe to be transferred to the casing pipe directly. The other PIP structure can be called non-compliant systems, in which, the carrier and casing pipes have structural connections through the bulkheads, which may either be placed at the pipeline extremities or at discrete locations, usually at intervals of a few kilometers along the pipeline length to transfer axial load. The possible buckling behavior of such PIP systems are discussed in this paper and some interesting results are presented.

KEY WORDS: HT, lateral buckling, post buckling, PIP systems, Riks method, contact analysis

INTRODUCTION

Pipe-in-pipe systems generally belong to two kinds of categories, namely, compliant and non-complaint systems. The compliant systems have connections between the carrier pipe and the casing pipe at close intervals either every two pipe joints by tulip, or by donut plate. In this case, the carrier and casing pipes expand uniformly along the pipeline and load transfer is continuous. In non-compliant systems, the carrier and casing pipes have structural connections through the bulkheads. The bulkheads may either be placed at the pipeline extremities or at discrete locations, usually at intervals of a few kilometers along the pipeline to transfer axial loads when the carrier and casing pipes may

move relative to each other. In addition, spacers or centralizer are used to prevent contact of the carrier and casing pipes in both categories. The centralizers are used mainly to maintain the flowline concentric within the casing pipe and are typically spaced 1-3m apart. However an alternative system has been used whereby insulation foam is employed along the pipeline's length.

This paper aims at the lateral buckling performance of untrenched HT pipe-in-pipe systems, and two typical pipe-in-pipe systems were analyzed by FE models to present the buckling characters of subsea pipelines of two categories. A comparison is also presented between the buckling performances of these two kinds of pipeline structures.

Thermal expansion of subsea pipeline, for carrying hot internal fluid, is partly induced differentially along its length by sea bed friction. The response behavior of such a pipeline was evaluated by Hobbs in a classic paper that has subsequently been extensively used in industry. Harrison et al. investigated the thermal expansion phenomenon in insulated pipe-in-pipe systems. Emphasis is placed on the calculation of pipe elongation, stresses and strains. A. Bokaian presents a comprehensive mathematical model for the thermal expansion of pipe-in-pipe and bundle systems. The carrier and casing pipes are assumed to have structural connections through bulkheads at extremities and spacers or centralizers to prevent contact of two pipes. The displacement and forces on the bulkheads and axial force in the carrier pipe are expressed by direct mathematical formulae. M.A. Vaz and M.H. Patel presents the equations of bending for the carrier and casing pipes of PIP systems, coupled by imposing force equilibrium and lateral displacement compatibility for both regular and irregularly pitched spacers. An eigenvalue solution of the resultant equation gave certain clarification on coupled elastic stability of pipe-in-pipe systems, though the presence of seabed friction and the mutual constraint axial and rotational between the carrier and casing pipes are ignored. So it is difficult to find an analytical solution considering adequate factors to describe the buckling performance of pipe-in-pipe systems and FE methods can be employed primarily to reveal the possible lateral buckling behavior of the untrenched HT PIP systems.

In this paper Arch length method (modified Riks method) is employed for the analysis on buckling process induced by high-temperature. ABAQUS software provides this algorithm and is used to analyze FE