

Numerical Analysis of Pipeline Dynamics in Seabed Laying

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ABSTRACT

The paper analyzes a mathematical model of the pipelaying from the stinger onto the seabed. The model is three-dimensional, geometrical and nonlinear; it takes into account the interaction between the pipeline (PL) and the seabed, at the contact zone of PL and the stinger at discrete points. To solve PL equations, a numerical method is proposed which enables one to overcome some difficulties associated with the presence of substantial nonlinearities in the equations, the changes of PL section lengths in time which span in the sea and are laid on the seabed and the stinger, as well as with the indefinite selection of the stinger contact rollers. The paper finds some mechanisms in the contact rollers' location along the stinger. Some examples are provided concerning the proper selection of the stinger and of PL parameters in laying PL at a depth of 320 m; it also gives an example of calculation of PL oscillations during the oscillating motions of the vessel.

INTRODUCTION

One of the most important problems in stinger laying of PL in the deep sea is to provide a sufficient strength of PL. This problem becomes extremely important when PL is laid at depths which are near to the limits in stinger laying, as it involves the provision of PL sufficient strength and some limitations on the stinger's maximum length, PL minimum weight in seawater and other parameters. The most effective method to solve this problem is to conduct a numerical experiment.

The majority of research works dealing with the problem of numerical modeling of the PL stress-deformation state in stinger laying refers to the static analysis (Ovunc, 1982; Yan and Pedersen, 1986). Their principal attention is devoted to PL section spanning in the water while the stinger is given as a continuous curve. In the work of Mayer et al. (1982), PL bending is taken into account at discrete points on the stinger rollers but the contact length of the stinger is considered as known. In actuality, such an approach is not permissible as the stinger contact length may change during the oscillating motions of the laying vessel and PL may bend at the last roller exceeding the ultimate stress. Vlahopoulos and Bernitsas (1990) treated the stinger as a continuous curve while the dynamics of PL section on the seabed are not taken into account at all. The latter is typical of practically all papers devoted to pipelaying mechanics.

This paper presents a sufficiently complete nonlinear model of three-dimensional dynamics of pipelaying from the stinger on the seabed, taking into account the displacements of the seabed section and PL bend on the stinger at discrete support points. The paper proposes a numerical method of solving the equations of PL motion, with most attention being paid to developing effective schemes of iterative processes. On the basis of numerical modeling some mechanisms

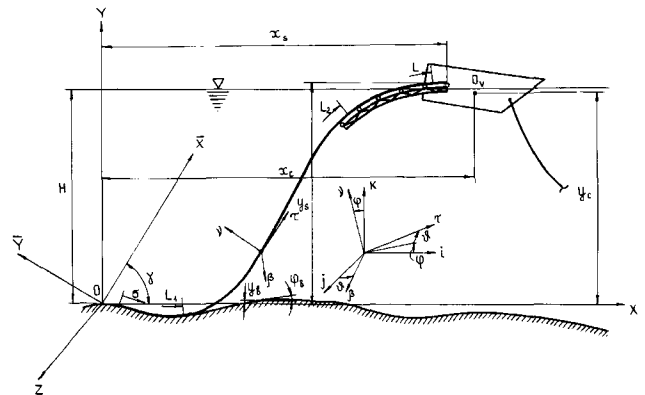


Fig. 1 Coordinate systems related to PL

have been found concerning the distribution of the stinger rollers in contact and without contact with PL at different parameters of the pipelaying. The paper analyzes some examples of using the developed calculation program of PL stress-deformation state for selection of PL and stinger parameters and modeling of PL oscillations in the time domain during the oscillating motions of the laying vessel.

MATHEMATICAL MODEL OF PIPELAYING

Coordinate Systems

Let us introduce the earth right-handed coordinate system $OXYZ$, connecting it with the initial undisturbed position of PL hanging from the vessel. The beginning O will coincide with the end of PL which is on the seabed. The axis OX will be oriented horizontally in a plane crossing the vessel mass center while the axis OY will be directed vertically upward (Fig. 1).

We shall use the Euler coordinate σ along the axis of the unstretched PL from the seabed end as an independent coordinate governing the position of PL axis points (Fig. 1). Every PL axis line point will be put on a natural trihedron (τ, ν, β) . Unit vector τ will be tangential to the PL axis, while the normal ν and the

Received March 20, 1995; revised manuscript received by the editors December 12, 1995. The original version (prior to final revised manuscript) was presented at the Fifth International Offshore and Polar Engineering Conference (ISOPE-95), The Hague, The Netherlands, June 11-16, 1995.

KEY WORDS: Pipelaying, stinger, dynamics, contact constraints, numerical method, pipeline stress.