Experimental Study on the Function of Flexible Spoilers in Protecting Submarine Pipeline

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ABSTRACT

When a pipeline is laid on a sediment bed, and subject to a current, the pressure difference between the upstream and the downstream of the pipe will induce a seepage flow underneath the pipe so that causing scour. The pressure difference is a main factor for the scour under pipelines. A new method to prevent the scour was proposed. Flexible spoilers were installed under the submarine pipeline to change the seepage flow field and pressure distribution, and reduce the pressure gradient between both sides of the pipeline. Experiment result shows that when the flexible spoilers reach or exceed a certain length, the pressure gradient is close to zero and the bottom scour almost disappears.

KEY WORDS: submarine pipeline; rigid spoilers; flexible spoilers; pressure difference; scour

INTRODUCTION

The submarine pipeline is one of the most important oil transport tools in ocean oil exploitation. It is an indispensable component in offshore oil production systems. Because the ocean environment is very complicated, the influence of many uncertain factors makes it very difficult to lay and manage underwater condition. Along with the exploitation of deep ocean oil, the application of submarine pipeline has become increasingly widespread. Hence more and more attention is being paid to the erosion and destruction problems caused by ocean dynamics. The spoiler was proposed to install on the top of the pipe in order to make the pipe self-burial. However, they are not fit for the rocky seabed (because rocky span shoulders support parts of the pipeline and prevent it sinking, fatigue failure is easy to happen due to part of the pipeline suspending). So the flexible spoiler was proposed to install under the pipe. The flexible spoiler can cover the seabed so that to keep the seabed be eroded.

1 Research Status

Li (Li et al., 1996) studied the net force acting on a seabed pipeline through physical model tests. He also conducted a study on the numerical model of a seabed pipeline and compared the results obtained from the two methods. Magda (Magda, 1997) used a two-dimensional finite-element method to simulate the wave-induced hydrodynamic uplift force acting on a submarine pipeline buried in sandy seabed sediments subjected to continuous loading of sinusoidal surface waves, neglecting inertia forces and assuming a linear-elastic stress-strain relationship for the soil and Darcy's law for the flow of pore fluid. Sumer, (B.M. Sumer et al., 2001) carried out many experiments to investigate the onset of scour below pipelines under current case and wave case. They got the critical condition for the scour start and the self-burial depth of the pipe. Kumar (Kumar et al., 2005) measured the wave pressure and uplift force caused by random waves on a submarine pipeline in clayey soil and investigated the influence of various parameters such as wave period, wave height, water depth, burial depth and consistency index of the soil on wave pressures around and uplift force on the submarine pipeline. The wave pressures were measured at three locations around the submarine pipeline. They found that the wave pressure and uplift force spectrum at high consistency index of the soil were smaller compared with those at low consistency index, and that just burying the pipeline in clayey soil could reduce the uplift force to less than 60% of the force experienced by a pipeline resting on the seabed for \( I_c = 0.33 \). Yang (Yang et al., 2005) investigated the occurrence of submarine pipeline spanning under the action of current numerically, analyzed the characteristics of the flow around the pipe by solving the N-S equations for incompressible fluid and analyzed the pressure distribution around the pipeline and shear stress along the seabed. Cheng (Li and Cheng, 2005) constructed a vertical two-dimensional numerical model for the submarine pipeline local scour under wave action, and they used a sinusoidal oscillatory flow instead of a wave, and solved the Navier-Stokes equation by the k-ε model. The interaction between ocean current, pipeline and seabed was simulated experimentally by designing an apparatus and analyzed by Yang (Yang et al., 2006) using the dimensional analysis method. Their primary experimental results indicated that the apparatus is capable of modeling the vortex-induced vibrations of pipeline and the sand scour around the pipeline in typical ocean environments. Xia (Xia, 2006) conducted a model experiment in a large wave flume for study local scour around submarine pipelines, observed and described the development of scour, measured the equilibrium scour depth, and established the relationship between the non-dimensional scour depth and the Keulegan-Carpenter number by nonlinear regression analysis. Zu (Zu and Huang, 2006) analyzed...