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Flow-Induced Moment and Lift for a Circular Cylinder with Cable Attachment

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ABSTRACT

This experiment was initiated to devise a vortex-suppression technique for a 6,000-m-long deep-ocean mining pipe to mitigate vortex-shedding-induced vibration and potential flow-induced detorquing of the pipe. One of the pipe and power cable configurations had the cable running parallel to the lift pipe axis. Test results showed significant drag and lift increase, plus a flow-induced torsional moment on the pipe and, surprisingly, a mean nonzero lift. Flow-induced torsional moment is an important concern because of potential torsional deformation and detorquing of the pipe during the deep-ocean operations. Measurements included mean and root-mean-squared values of lift, drag, torsional moment, and frequency and relative intensity of the shed vortices. Vortex-shedding characteristics were further investigated through flow visualization (dye trace) techniques. Bare cylinder results confirmed conclusions already available from other tests. The tests were conducted in a water tunnel with a 10 ¥ 14 cm test section. The tests examined cable diameters of 3.05 cm to 29.97 cm and pipe diameters of 25.4 cm to 127.0 cm, respectively. The vortex-shedding suppression results will be published separately.

INTRODUCTION

Ocean mining systems studies require accurate prediction and control of pipe-bottom motion (Brink and Chung, 1981) for efficient mining operations. One of the potential problems is operational restrictions caused by vortex shedding, which can be resolved by using vortex-shedding suppression devices along part of the mining pipe (Chung and Whitney, 1981; Whitney and Chung, 1981). To address this problem, we tested perforated shrouds, strakes (helical wrapping of the power cables), and cables running straight down the mining lift pipe (Fig. 1). Results for the shroud and strake configurations will be published later (Chung, et. al., 1994).

The straight-down cable arrangement was included because it is relatively easier to implement at sea than the other configurations. Configurations with two straight electromechanical (EM) power cables have been used for a test mining in the Pacific Ocean. A (lift) pipe with the straight-cable configuration will encounter flow-induced torsional moment and lift unless it is aligned symmetrically with respect to the cross flow. Pipe torsion may create unfavorable restrictions on the pipe bottom heading control and potential pipe detorquing. Torsional moment is one of the postulated causes for detorquing of a pipe in previous ocean mining operations.

The present part of the water-tunnel test was to determine flow-induced torsional moment on the pipe and increase of drag and vortex-shedding intensity generated by the flow asymmetry around the pipe. The test was carried out for a range of parameters representative of ocean operations. Descriptions of model configurations, parameters, and test scope are followed by measurements of drag, lift, torsion, vortex-shedding frequency and flow visualization. The straight-cable models were built to measure the torsional moment for various flow angles of attack.

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KEY WORDS: Vortex shedding, flow-induced vibration, torsional moment, mean and unsteady lift, drag, circular cylinder, cable attachment, vortex intensity, ocean mining.

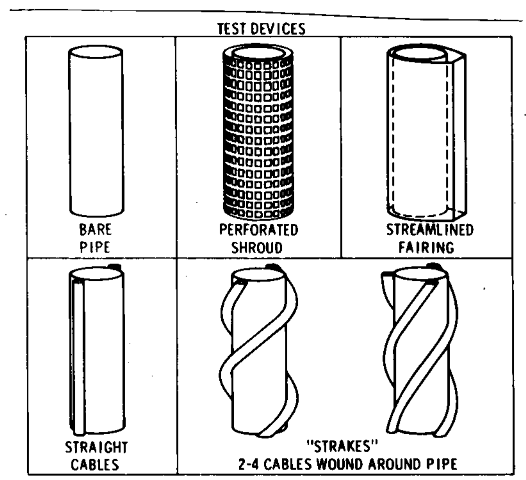

Fig. 1 Three basic configurations of vortex-suppression devices

MODEL DESCRIPTION AND TEST SCOPE

Description of Models

Five configurations (Fig. 2) were tested:

- Bare cylinder
- Cylinder with two straight cables (two cable diameters)
- Cylinder with three straight cables (two cable diameters)

Bare-Cylinder Model. The bare-cylinder model is made of steel rod. Its dimensions are 10.56 cm (4.16 in) in length and 2.69 cm (1.06 in) in diameter. It is cantilever-mounted in the test section, and the gap between the model tip and the wall of the test section is 0.4 mm.

Straight-Cable Models. The bare-cylinder model is used as core for the straight-cable configuration. The latter configuration