Contractile floating reservoir for confinement and recuperation of oil slicks

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Introduction

In recent years, major oil spills such as Erika and Prestige incidents and many smaller ones have given rise to a worldwide marine environmental concern. One of the most successful devices for containing and facilitating the recovery of spilled oil and one, which does not endanger or alter the environment, is the oil containment boom.
A new system of oil containment booms has been designed by Cavalli (1999) to contain and clean up oil spills. It can be used around or in close proximity to tankers and offshore platforms. The floating reservoir is made of floats giving buoyancy to the structure of a high-resistance membrane made of Kevlar® avoiding oil spills beneath the floats. Appropriate ballast provides the stiffness of the skirt.
In this new system, oil spill is encircled by the reservoir avoiding its spreading. The reservoir can be subdivided using ropes in order to increase the oil layer thickness. This improves the pumping operation in reducing water drawing up. This system can permanently be installed on tankers or platforms and deployed around the slick immediately. Afterwards, the oil slick contained by booms can be towed to safe locations, for example near the coast, where the procedure of recovery is less influenced by wind and wave impacts.

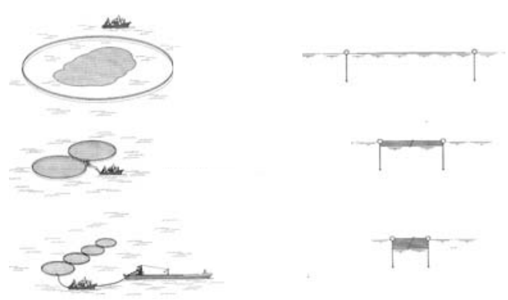

Figure 1: Concept of Cavalli system: confined oil slick by a special reservoir (left) and increasing thickness of oil slick by dividing it (right)

Background

The feasibility of this contractile floating reservoir was investigated systematically using a physical model. Tests have been conducted to evaluate the behavior and effectiveness of Cavalli system under different wave conditions and towing configurations. Three configurations; simple, double and quadruple ones, have been tested in a wave tank as well as in a towing tank.
The results of conducted tests proved the effectiveness of the Cavalli system.

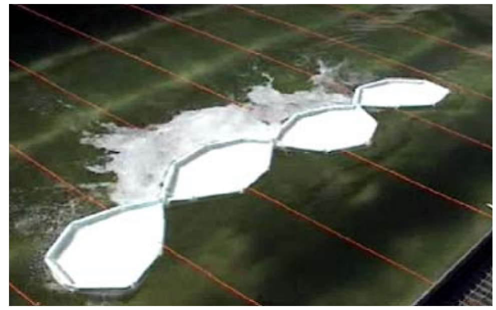

Figure 2: Preliminary tests with floating oil barrier; quadruple configuration under wave impact in wave tank

Objectives of the project

In an ongoing study, the efficiency limits of the Cavalli system under real life scenarios are investigated. The main aim is to evaluate the behaviour of a flexible skirt under different wave and current conditions for a range of oil properties.

Methodology

This study will be done, using three different approaches: theoretical developments, physical modelling and numerical modelling.
In theoretical part, the static behaviour of the booms as well as deformed shape of towed reservoir and deformation of skirt due to hydrodynamic forces will be studied.
Physical modelling consists of two-dimensional tests, which are going to be conducted in a flow channel, and three-dimensional tests, which are going to be undertaken in wave and towing tanks. After realizing the behaviour of models under different conditions, some full-scale test will be performed to prove what have been found in model tests.
In order to understand better the behaviour of slick oil behind a flexible barrier numerical models will be built up. Numerical models should obtain a satisfactory agreement with experimental findings. Afterwards, they can be used to evaluate the efficiency of the containment system under various conditions, instead of utilizing expensive and difficult experimental tests. Numerical modelling includes two parts: hydraulic modelling of the behaviour of slicked oil and structural modelling of the behaviour of a flexible barrier due to hydrodynamic pressure. For modelling the fluid medium, finite element and/or boundary element may be used. The free surface of the water and oil-water interface will be determined based on a time stepping integration. For the interaction analysis, a sequential coupled analysis will be used. The pressure filed is applied to the structure and deformed shape of the structure is evaluated. The mesh of the fluid domain is modified in the next step and the analysis will be repeated. These sequences are continued until a situation in that the modification of the pressure filed and structural deformations are below a prescribed tolerance.