Motion Simulation of Subsea Vehicles

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ABSTRACT

Motion dynamics of subsea vehicles are reviewed on the basis of vehicle configuration in order to develop a simulation method for vehicles of a general shape. After an initial literature survey, extensive hydrodynamic tests have been carried out with an existing tethered Remotely Operated Vehicle (ROV), which was used as a test vehicle, and with its full-scale model. The experiments have given data of maneuvering capabilities, and of hydrodynamic characteristics of small subsea vehicles. A simulation method has been developed on this basis to compute the vehicle trajectory in the time domain as a function of different control commands. The method can be applied to any subsea vehicle controlled by thruster units.

NOMENCLATURE

\( \Delta t \): time interval
\( \alpha \): angle of attack in vertical plane
\( \beta \): drift angle in horizontal plane
\( (\Phi, \Theta, \Psi) \): Eulerian angles
\( \rho \): water density

INTRODUCTION

A programme of underwater technology research was undertaken by the Technical Research Centre of Finland (VTT) during the years 1987-1989. This programme was of an extent of 22.5 person years, and comprised eight research projects. These covered a wide range of technology, including underwater material technology, flexible risers, and underwater vehicles with their equipments, especially manipulators. One of the projects was motion dynamics of submersibles, described in this paper.

Subsea vehicles can be divided into the following groups on the basis of vehicle shape:
1) Slender vehicles
2) Non-slender vehicles
   - Open-space-frame vehicles
   - Shell-frame vehicles

The main interest in this project has focused on vehicles of a more general shape than a slender vehicle, say, a naval submarine. From a hydrodynamic point of view, the non-slender bodies are in many cases able to move in any direction, which complicates the formulation of the expressions for external forces and moments. Many approximations used with slender bodies, such as linearization, or decoupling of different plane effects, cannot be used with subsea vehicles in general. A special group of problems arises for tethered vehicles operating in strong sea currents, where the cable forces dictate the operational ability of the vessel.

The following sections will describe ROV and model tests performed in the towing tank, and the most important test results. The formulation of the equations of motion for a tethered subsea vehicle will be presented, as well as simulated results with the presented formulation.

FREE-RUNNING ROV TESTS

An important aspect of the project was the possibility of performing maneuvering tests in a towing tank with a tethered ROV Pluto (Given, 1986), as shown in Fig. 1. This was chosen as a test vehicle in the project. As no hydroacoustic position measurement system was at our disposal, an optical system was developed to