CHALMERS
UNIVERSITY OF TECHNOLOGY

Fluid Structure Interaction Analysis: Multidisciplinary Modelling of Water Piston Oscillations in Wave Energy Converters

Background and motivation

Wave energy convertors (WEC) convert heaving motions of buoys, which are driven by incoming ocean waves, intoelectricity. WECs developed by Waves4Power is a successful case. Their buoy system, WaveEL, is shown in Figure 1. The piston in the vertical tube oscillates up and down relatively owing to buoy heaving motions. Obviously, the modes of the piston oscillation affect the efficiency of energy harvesting. As the oscillation essentially depends on the interaction between the piston and the water inside the tube, it is interesting to investigate the interaction. However, the interaction is difficult to predict because of the formation of flow vortices around the piston, which cannot be modelled with linear reduced-order models.

Figure 1: the WaveEL buoy system produced by Waves4Power (https://www.youtube.com/watch?v=4eciiGwwLeY).

Objectives

This thesis work aims to

1) analyse the fluid-structure interaction (FSI) of flow across a water piston, in particular, the nonlinear effects of pressure drop, velocity variation, and vortex evolution process;
2) model the nonlinear effects and couple it to a reduced-order model;
3) compare different high-fidelity simulation methods that are specifically developed to compute the current FSI scenario.

Methods

The FSI will be simulated using a reduced-order model and high-fidelity computational methods, including the finite element method (FEM) and the finite volume method (FVM) that is commonly used in computational fluid dynamics simulations (CFD). The reduced-order model was developed by Waves4Power, and it will be coupled with the high-fidelity simulations as part of the project.

Number of students: 2 students: 1 from Chalmers and 1 from Karlstad University.

Prerequisites: computational fluid dynamics, or finite element analysis.

Tasks

- Simulate the FSI of a water piston in stationary and dynamic operation conditions.
- Compare different high-fidelity simulation methods: FEM and FVM.
- Analyse nonlinear FSI effects in terms of pressure drop and the evolution of flow vortices.
- Identify the key parameters that dominate the nonlinear dynamics of the FSI.
- Couple the nonlinear dynamics to a reduced-order model.
- Write a thesis report.

Contacts

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