Comparative study of the hydrodynamics of a heaving wave energy converter using linear and non-linear wave theory

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Wave Energy is a potential source of clean electricity that can make a significant contribution to the de-carbonization of the world's electricity supply, and can be harvested by using wave energy converters (WECs). In order to assess the performance and survivability of WECs, the hydrodynamic forces and body motions of the floating devices have to be calculated. Most investigations concerning WECs apply linear potential flow theory, which has the major drawback of assuming small amplitude oscillations of the WECs, resulting in an underestimation of the acting forces under extreme sea states [1]. Therefore, it is more appropriate to use fully rotational non-linear models, e.g. models based on Smoothed Particle Hydrodynamics (SPH), which is a Lagrangian meshless method used within the field of Computational Fluid Dynamics (CFD).

The defining characteristic of a WEC, distinguishing it from a simple floating body, is the power take-off (PTO) system, which converts the mechanical energy into useful electricity. In most cases this PTO system is modelled as a simple linear damper, which is oversimplified compared to e.g. a more realistic hydraulic PTO system. These numerical simplifications can result in an overestimation of the absorbed wave power by the WEC of up to 150% [2].

The aim of the present research is to perform numerical SPH simulations and compare the obtained results to those from the simplified linear potential flow theory. More specifically, a heaving WEC will be simulated using a coupled NEMOH – WEC-Sim model [3,4] and the average absorbed power and acting forces will be determined in different sea states. Thereafter, the heaving WEC will be simulated using DualSPHysics, a non-linear SPH solver. Again, the average absorbed wave power by the WEC and the hydrodynamic forces acting on the WEC will be calculated and compared to the results obtained using the linear method. This will allow to define in which cases applying linear potential flow theory leads to excessive errors.

DualSPHysics will be coupled to an accurate model of the PTO system, which will clarify its impact on the hydrodynamics of the WEC and on its average absorbed power. The WEC will be moored to the seabed and thus in order to assess the effect of the mooring lines on the WEC's hydrodynamic behaviour, a DualSPHysics – MoorDyn coupling will be further developed. This coupling also allows modelling of moored floating structures in general, such as floating wind turbines.

Finally, the obtained numerical results will be validated using the experimental data of the 'WECfarm' project, which will be carried out in the Coastal & Ocean Basin (COB), Belgium. During this project, several heaving cylindrical WECs will be installed in a farm configuration and subjected to various wave conditions. These experiments will provide data of the WECs' motion, the forces acting on the WECs and the modified wave field surrounding the WEC farm.

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