INORE European Symposium 23 - 31 August 2019 Nocera Umbra, Italy

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

Nicolas Quartier (Nicolas.Quartier@UGent.be)
Ghent University, Ghent, Belgium

Vicky Stratigaki (Vicky.Stratigaki@UGent.be)
Peter Troch (Peter.Troch@UGent.be)

How can a heaving wave energy converter (WEC) be modelled accurately in operational and extreme sea states?

Modelled WECs and PTO-systems

Heaving WEC

- Flat shape increases radiation effect
- Based on commercial WECs: Carnegie, SINN Power

Fig. 1: Sketch of the modelled heaving WEC.

PTO-system

- Linear PTO-system
- Coulomb damping, as a simplified model of a hydraulic PTO-system

Using the numerical model, WEC-Sim

- Model PTO-system
- Time domain
- Calculate absorbed power

DualSPHysics

- DualSPHysics applies the Smoothed Particle Hydrodynamics method (SPH), a Lagrangian meshless method.
- DualSPHysics discretizes the fluid in particles: physical quantities are computed as an interpolation of the values of neighbouring particles.
- Allows calculations of WECs in extreme sea states.

Fig. 2: Heaving WEC in extreme wave conditions.

Using the numerical model, DualSPHysics

- Coupled with Chrono Engine: allows modelling effect of PTO-system
- Time domain

Comparison WEC-Sim vs. DualSPHysics

- WEC-Sim overestimates heave motion of WEC at resonance due to non-linear effects.
- Vorticity in close proximity of the WEC is visible in DualSPHysics. This vorticity increases with increasing relative velocities and causes energy losses.
- DualSPHysics applies correct wave-shape according to Stokes 2nd order theory.
- Optimal PTO-damping for linear or Coulomb PTO-system seems to be larger in DualSPHysics than in WEC-Sim.
- DualSPHysics can be used to estimate the drag coefficient of the WEC. Viscous drag can be included in WEC-Sim, resulting in more realistic results.

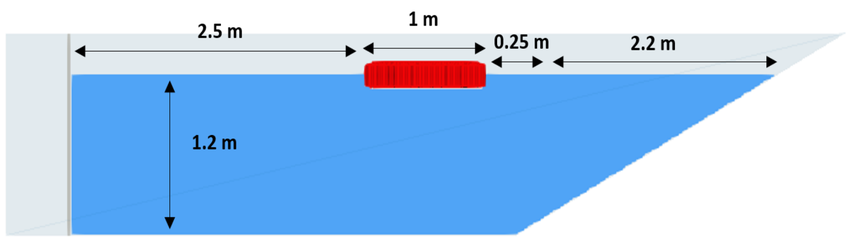

Fig. 3: Dimensions of numerical wave tank in DualSPHysics for T = 1.2 s, H = 0.15 m.

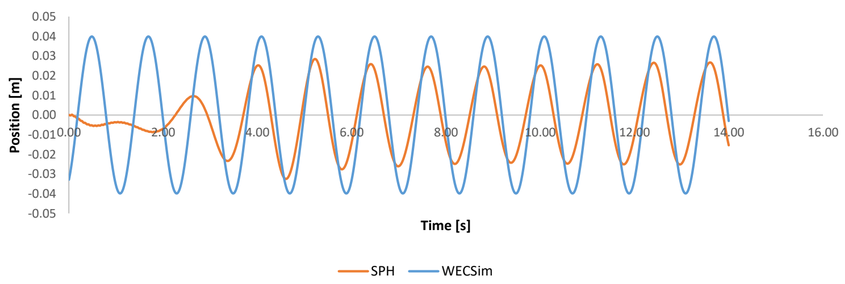

Fig. 4: Heave displacement of the WEC with linear PTO-system, T = 1.2 s, H = 0.15 m.

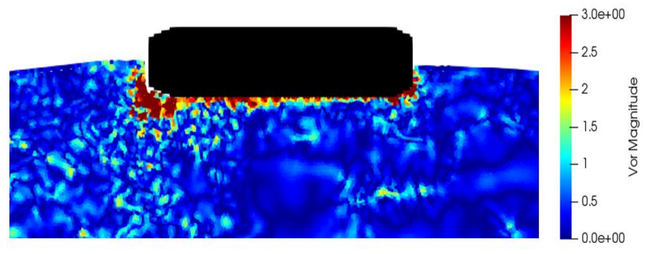

Fig. 5: Vorticity in the proximity of the WEC [1/s].

Effect of the PTO-system on the non-linear effects

- Adding a PTO-system causes a phase shift of the WEC's heave motion relative to the wave elevation. This increases the relative velocities between WEC and water particles, resulting in higher vorticity.
- Difference between linear damping and Coulomb damping still to be further investigated.

Future work

- Add a drag coefficient in WEC-Sim to consider the effect of viscous drag.
- Compare the modified wave field with both PTO-systems in DualSPHysics with the results from linear calculations

This research is being supported by the Research Foundation Flanders (FWO), Belgium - 330 FWO.OPR.2.0 - FWO research project No. 3G029114