Analysis of flap-type Wave Energy Converters with OpenFOAM using the dynamic mesh method

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Over the years, various configurations of flap-type Wave Energy Converters (WECs) have been proposed by many researchers. Flaps have been investigated as standalone devices or combined in multi-body systems, while different characteristics (e.g. geometry of the flaps, location of the rotation axis, installation depth) have been considered in the proposed WECs. In this context, a new multi-body floating system with multiple flap-type WECs has been proposed in [1]. In that study, the hydrodynamic response and the power performance of the proposed system were investigated in the frequency domain using the potential flow theory. The flaps' rotation relatively to the platform was described by introducing the generalized modes' concept, while emphasis was given on the interactions between the system's flaps.

The results of this investigation indicated extreme values in the response of the WECs, at frequencies where resonance phenomena occur, attributed probably to viscous damping effects. Motivated by this, the present research aims at assessing and quantifying viscous damping effects on the response of the aforementioned system by conducting a Computational Fluid Dynamics (CFD) analysis. To this end, the free-decay motion of a flap-type WEC is simulated in a CFD model. The numerical model was set up in OpenFOAM, considering a rectangular flap and an elliptical flap similar to the one proposed in [1]. Within the context of COST Action CA17105, a Short Scientific Mission (STSM) was granted to the first author of this abstract for implementing the numerical set up of the CFD model. The examined flap configurations are fully-submerged and their initial position is defined by applying an initial rotation to the flap. Several tests have been performed with different angles of release. Since the examined flap is rotating about a fixed axis, the mesh has to be adapted at every time step. Accordingly, the dynamic mesh method is selected for the CFD simulations along with the 'interDyMFoam' solver. This solver utilizes a Volume-Of-Fluid (VOF) phase-fraction based interface capturing approach and it can apply adaptive re-meshing for addressing the required mesh motion. The rotation of the flap is specified as a combination of constraints in the 'sixDoFRigidBodyMotion' library of the solver. Since the dynamic mesh is a complex process in CFD modelling, a series of trial simulations was implemented to address correctly the physical problem and achieve the required motion of the mesh.

The results of this research will be further utilized for enhancing the numerical modelling of the system proposed in [1] and for optimizing its design.

Reference

[1] Sismani G and Loukogeorgaki E (2020). "Frequency-based investigation of a floating wave energy converter system with multiple flaps", Applied Mathematical Modelling Journal, 84C, pp. 522-535.

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