Numerical Simulation of Multiple Vertical Axis Hydrokinetic Turbines using Variational Multiscale Methods

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ABSTRACT

The performance of multiple hydrokinetic turbines is very challenging to measure during the design phase, instead the authors present in this paper a full-scale, 3D numerical study of an array of two vertical axis hydrokinetic turbines (HVAT). The time-dependent, 3D, incompressible Navier—Stokes equations are discretized using the finite elements. The Arbitrary Lagrangian-Eulerian Variational Multi-scale [1] (ALE-VMS) formulation is used to govern the highly turbulent problem of wake-structure interaction. In addition, the sliding interface formulation is adopted to handle the components in a relative motion, i.e. rotor-tower interaction. Weak enforcement of essential boundary conditions [2] is used for the solid structure surfaces. This relax the requirements on a boundary layer resolution while still providing a good accuracy.

First, a single turbine is simulated, and the computed torque is validated against experimental measurements with an apparent degree of agreement. Next, the computation of two turbines is performed to investigate the behaviour of the downstream turbine placed in the wake of the upstream turbine. The results assure the robustness of the ALE-VMS formulation and how it can be used in marine/offshore engineering applications.

REFERENCES

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[2] Bazilevs Y, Michler C, Calo VM, Hughes TJ. Weak Dirichlet boundary conditions for wall-bounded turbulent flows. Computer Methods in Applied Mechanics and Engineering. 2007 Nov 1;196(49-52):4853-62.