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Numerical Study and Comparison of Cavitation Effects for an Axial and a Cross-Flow Hydrokinetic Turbines

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ABSTRACT

Hydrokinetic turbines have gained a lot of attention in the past years for their high-power extraction potential in river and tidal currents. Cavitation poses a threat to this power extraction due to its detrimental effects on turbine performances. Indeed, cloud or sheet cavitation may change the effective hydrodynamic bodies of the blades and even induce boundary layer separation resulting in power extraction limitations. The level of threat depends on the deployment site, operating conditions, type of turbine as well as design choices. This presentation will focus on two types of hydrokinetic turbines, namely the Axial-Flow Turbine (AFT) and the Cross-Flow Turbine (CFT), two fundamentally different technologies. The former experiences steady hydrodynamics while the latter unsteady hydrodynamics with its angle of attack and relative velocity at the blade varying along its cycle. This major difference leads to interesting and distinct cavitation behaviors.

This work focuses on the effects cavitation has on the hydrodynamics and the power extraction of the turbines. Typical values of power losses due to cavitation for various deployment conditions are covered. The argumentation on which normalization should be used for a better comparison and uniformization between technologies is presented. That is, using the flow speed as the reference velocity is preferable when comparing different technologies that may operate at various tip-speed ratios. Some solutions or design modifications that can be made to reduce the negative effects of cavitation are also explored. For example, changing the blade pitch angle for CFT is a simple modification that can greatly reduce risks of cavitation without affecting the overall power extraction. The authors also recommend designs operating optimally at lower tip-speed ratios when cavitation may be problematic.

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