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STRUCTURAL DESIGN OF A HORIZONTAL-AXIS TIDAL CURRENT TURBINE COMPOSITE BLADE

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ABSTRACT

This paper describes the structural design of a tidal turbine composite blade. The structural design is preceded by two steps: hydrodynamic design and determination of extreme loads. The hydrodynamic design provides the blade external shape, i.e. the chord and twist distributions along the blade, which result in optimal performance of the tidal turbine over its lifetime. The extreme loads, i.e. the extreme flap and edgewise loads that the blade would likely encounter over its lifetime, are associated with extreme tidal flow conditions and are obtained using a computational fluid dynamics software. Given the blade external shape and the extreme loads, we use laminate-theory-based structural design to determine the optimal layout of composite laminas such that the ultimate-strength and buckling-resistance criteria are satisfied at all points in the blade. The structural design approach allows for arbitrary specification of the chord, twist, and airfoil geometry along the blade and an arbitrary number of shear webs. Certain fabrication criteria, e.g. each composite laminate must be an integral multiple of its constituent ply thickness, are imposed. In the present effort, the structural design uses only static extreme loads; dynamic-loads-based fatigue design will be addressed in the future. Following the blade design, we compute the distributed structural properties, i.e. flap stiffness, edgewise stiffness, torsion stiffness, mass, moments of inertia, elastic-axis offset, and center-of-mass offset along the blade. Such properties are required by hydro-elastic codes to model the tidal current turbine and to perform modal, stability, loads, and response analyses.