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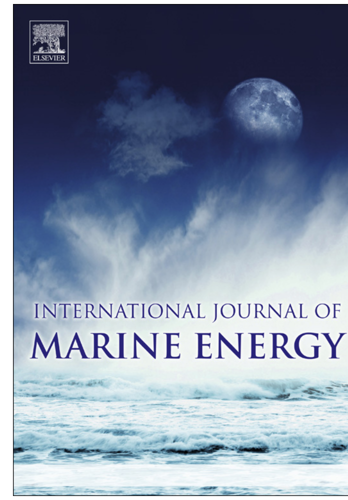

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Passively Adaptive Tidal Turbine Blades: Design Tool Development and Initial Model Verification

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Abstract—Fixed pitch passively adaptive tidal turbine blades made of non-homogeneous composite materials have the potential to reduce blade and structural loads, shed power above design conditions, reduce cavitation inception, and reduce the effects of fatigue loading. Due to the flexibility of these blades, a fluid-structure interaction design methodology is required. This paper outlines the development of a coupled finite element (FEM)-blade element momentum theory (BEMT) design tool developed to iterate between the structural (deformation and stresses) and hydrodynamic (power and thrust loads) responses of passively adaptive blades. Such a FEM-BEMT design methodology provides an early stage tool with minimal computational requirements compared to computational fluid dynamics-FEM coupled codes. Both the BEMT and FEM components of the design code have been verified independently, with results presented here. Results using the design tool in a case study of a small-scale turbine with three pre-twisted fixed pitch passively adaptive blades, operated using variable speed control, showed load mitigation and power shedding at flow speeds above design conditions, and increased overall power capture between the cut-in speed and the design speed.

Keywords— Passively adaptive blades, Composite stress analysis, Finite element model, Blade element momentum theory, Design tool

NOMENCLATURE

C_p	Power coefficient (-)
C_T	Thrust coefficient (-)
F_T	Force of thrust (N)
i	Iteration number (-)
Q	Torque (Nm)
U_∞	Inflow velocity (m/s)
λ	Tip-speed ratio (-)
ρ	Density (kg/m^3)
ω	Turbine Rotational velocity (rad/s)
ϕ_i	Induced twist (°)