EFFECT OF BLADE PITCH ON THE PERFORMANCE AND DYNAMIC LOADING OF AN AXIAL-FLOW MARINE TURBINE

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Optimal design of an axial-flow marine turbine typically assumes steady, uniform flow across the rotor plane, but velocity fluctuations at tidal sites are introduced by mean velocity shear, inhomogeneity, and turbulence, resulting in asymmetrical, unsteady loading and power fluctuations. This can have a detrimental effect on the reliability and life span of turbine components [1]. Existing experimental studies of axial-flow marine turbines show that turbulent structures of different length-scales interact with the turbine blade and wake flows differently, with a wide range of impacts on turbine performance and dynamic loading [1,2]. A study by Henriques, et al. [3] demonstrates that increasing blade pitch from the optimal angle offers a reduction in thrust loading with moderate reduction in power.

Additional data on the impact of blade pitch on individual blade loads and rotor integrated thrust is necessary to achieve greater load reductions and inform the development of active pitch control. Dynamic loading on the hub and a single blade of a 0.45-m diameter, three-bladed axial-flow tidal turbine was investigated using load cells installed on the main shaft and one of the blade roots. The turbine was tested in a 0.75-m wide by 0.6-m deep open channel flume under various turbulent inflow conditions at five different blade pitch angles (-5.0°, -2.5°, 0°, +2.5°, +5.0°) and tip speed ratios ranging from 2 to 10. Performance curves at various pitch angles demonstrate the trade-off between load reduction and efficiency and will be used to develop active pitch control strategies (Fig. 1). Measurements of cyclic loading on the blades during turbulent inflow conditions suggests that dynamically controlling the blade pitch over each rotor revolution, in response to the inhomogeneous velocity input, could further reduce fatigue loading.

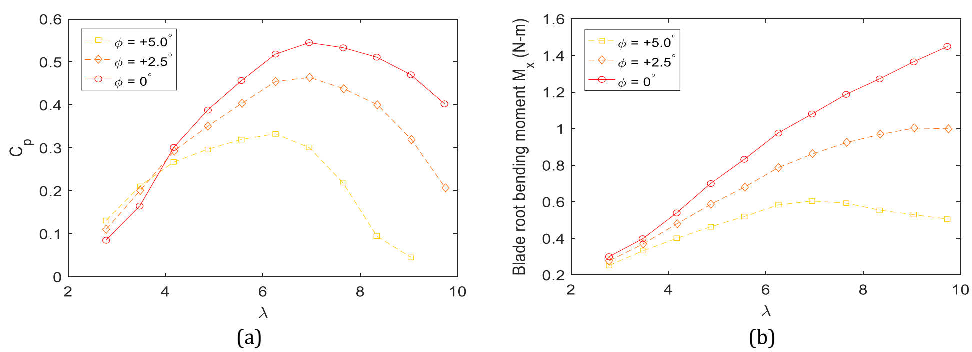

Figure 1. (a) Power coefficients and (b) blade root bending moment for various tip speed ratios and blade pitch angles in 0.5 m/s flow with a blockage ratio β = 35%.

ACKNOWLEDGEMENTS
Funding for this research was provided by the United States Naval Facilities Engineering Command.

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