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Active Pitch Control for Cross-Flow Water Turbines

Cross-flow water turbines (CFTs) are complex devices that, while studied extensively, have seen little implementation relative to the conventional horizontal-axis (wind) turbine. This research intends to prove that active pitch control (APC) methodology can significantly improve performance of CFTs. Computational fluid dynamics (CFD) simulation will provide the design space to determine an optimal control configuration, while experiments will be conducted in the future to validate simulation results. Preliminary investigation suggests that passive pitch control (APC) can increase coefficient of power of the CFT, which represents rotor output and is therefore a main indicator of improved performance. However, PPC estimates the overall flow field by a simple mathematical relation that only takes into account turbine radius and velocity. APC provides the ability to measure the flow field during simulation, giving the ability to specify exact values for more accurate control and take into account the dynamic fluctuations of each turbine blade. The model is a straight-bladed CFT with three cambered blades and a radius of 0.108, along with dimensions from the Civil Engineering water flume. A proportional-integral (PI) controller is used in tandem with two-dimensional CFD to drive blade rotation rate. Individual blade moments are selected as input parameters and each blade is controlled separately based on fixed-pitch moment data. Initial results show improved performance due to a wider positive torque bucket and a higher starting pitch angle per revolution.