Advanced Signal Processing for Marine Hydrokinetic Turbine Fault Detection

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Abstract

MHK turbine fault detection which relies on sensors that mounted to the devices are intrusive and subject to sensor failures. An adaptive algorithm capable of detecting rotor blade faults in MHK turbines non-intrusively is proposed, which relies on the application of the Hilbert-Huang transform (HHT) to a generator's electrical power output. The combination of Empirical Mode Decomposition (EMD) and its variants with the Hilbert Transform (HT) is used to extract changes in the frequency spectra of power output at characteristic frequencies, in order to classify hydrodynamic asymmetry fault conditions. Specifically, the average power around the 1P frequency is normalized with respect to overall output power, and observed to increase as the severity of the fault increases, as shown in Figure 1.

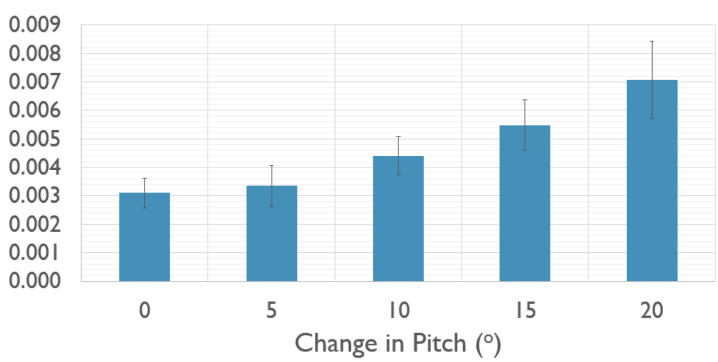

Figure 1: Normalized power amplitude at fault frequency for hydrodynamic asymmetry faults of increasing severity using default parameters.

The algorithm is tested on data produced by an improved high-fidelity MHK simulation platform [1] that was developed using the FAST code from the NREL [2]. A stochastic, full-field turbulence simulator called TurbSim was used to generate three-component water velocity vectors on a two-dimensional grid that is fixed in space [3]. TurbSim numerically simulates water turbulence using its TIDAL-spectral model, which generates simulated turbulence corresponding to tidal channel data empirically derived from the Admiralty Inlet in Puget Sound, Washington [4]. Hydrodynamic asymmetry faults are modelled by adjusting the pitch angle of one blade out of alignment with the other two. Parameter tuning is used to determine both minimum requirements for 95% detection accuracy under varying degrees of asymmetry and optimal algorithm parameters overall. These parameters include decomposition method, sampling frequency, and sampling time. Once optimal parameters are determined, they are used as defaults for further testing and verification. Future research will extend the applications of this algorithm to simultaneously detect bearing and gearbox faults in addition to rotor blade faults. This research will help to decrease the Levelized Cost of Energy (LCOE) (i.e., lower maintenance costs) and make MHK more competitive with other renewable energy.

Acknowledgements

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References

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