Hybrid Modelling Approach for Twist Optimization of RM1 OCT With Actuator Line Method Modelling

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Designed a hybrid modelling methodology that could simulate the RM1 using an actuator line method and optimize blade twist working alongside a data driven reduced order model

Introduction

The global demand for Energy keeps rising and hence new forms for energy sources continue to be important to satisfy this rise in demand. In the past few years, the interest in offshore wind and Ocean Current Turbines has increased, and hence more research and development is being conducted in these fields. The work specifically attempts to improve the feasibility of the OCTs with the help of adaptive blade technology for improved energy capture, reduced fatigue loading, hence enhancing the power quality and reducing the levelized cost of energy (LCOE) [1,2,3]. The authors have developed adaptive blade design for wind applications and in this work propose adapting these blade designs for the sake of OCTs. These adaptive blades are more necessary for OCTs due to the complex and dynamic marine environment.

Methodology

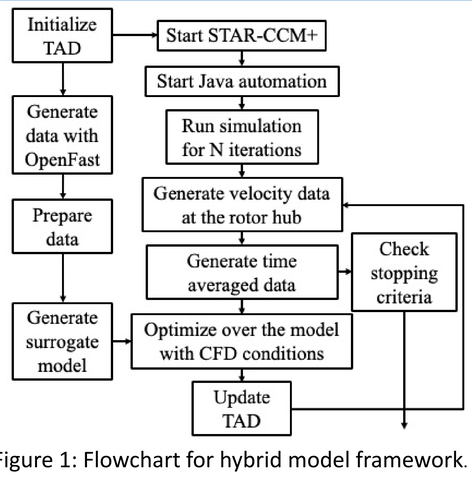

Figure 1: Flowchart for hybrid model framework.

Reduced Order Modelling

A 2-layer Neural Network was constructed to predict the blade response based on the OPENFast data previously generated.

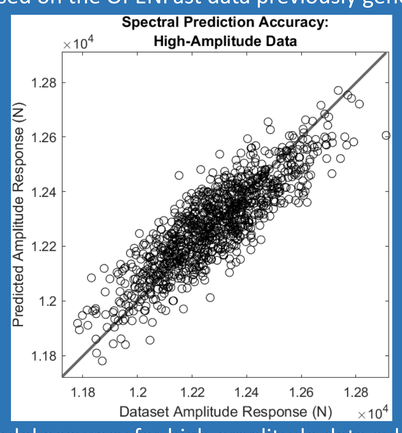

Figure 2: NN model accuracy for high-amplitude data subset, for training and validation data.

CFD simulation

LES simulation with a domain size of 240x240x500m. The mesh has progressively finer refinement. The blade characteristics are defined by 9 blade sections across the blade span. These are used to generate source terms for the actuator line method to be then interpolated in the LES mesh

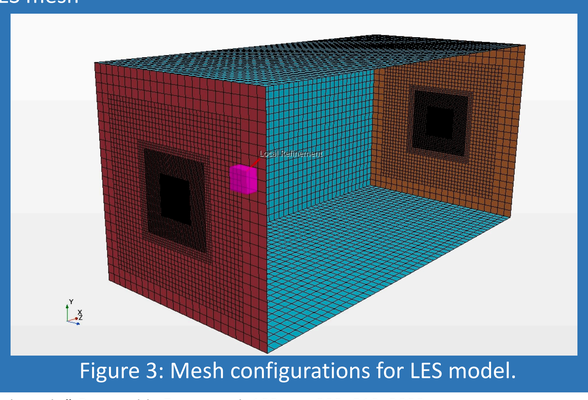

Figure 3: Mesh configurations for LES model.

RESULTS

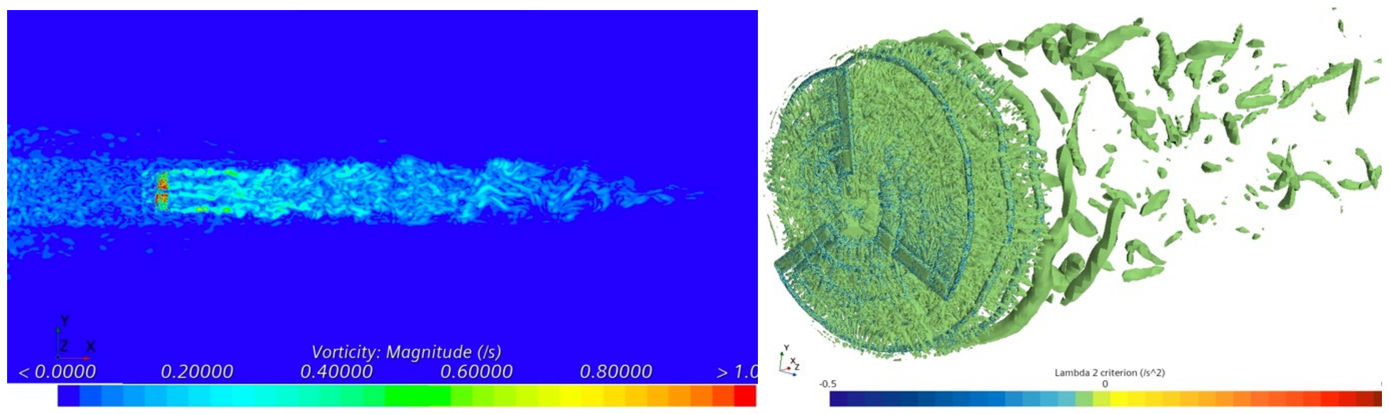

Figure 4: Vorticity plot at the rotor plane (Left) and the Lambda 2 criterion (Right) plot showing vortex structures and tip vortices.

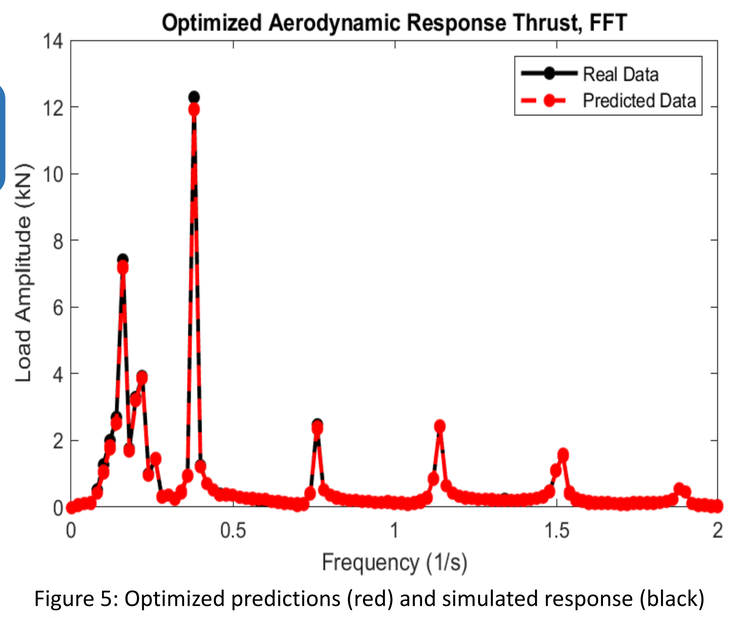

Figure 5: Optimized predictions (red) and simulated response (black) of spectral thrust response, truncated.

Table 1. Optimal total damage fractions and percent reductions, by material, for reference aerodynamic case.

	Steel	Aluminum	Composite
b	3	6	9
D_{Total} Ratio	0.918	0.840	0.769
D_{Total} Reduction (%)	8.206	16.04	23.09

This study showed load reduction for a data driven method and established the feasibility of this hybrid modelling approach. During this study the NN model demonstrated high prediction accuracy. A data driven models, and a genetic algorithm-based Pareto optimization was used for various blade materials, achieving 23.09% reduction in fatigue damage. Initial analysis also shows feasibility of the framework to successfully analyze the twist distribution and varying chord length characteristics. The velocity magnitude shows mixing and momentum recovery downstream of the rotor as well as turbulent mixing. The vorticity and the lambda 2 criterion both show the nature of the vortex shedding at the tip and the critical wake mixing that need to be studied to better

Conclusion

This paper discussed and shared the results from modelling the RM1 turbine. The authors performed and presented the results from this the RM1 simulation with the actuator line method. They will proceed to go ahead with the optimization step to implement the framework for optimization of fatigue loading and energy extraction for the RM1 turbine. . Previous work showed these frameworks to be effective at reducing the fatigue loading through a TAD search algorithm with a reduction of 23.09% for composite materials. These results are promising for showing functionality of the methodology and promises to be vital in the continued study of OCTs.

[1] Pisetta, Gabriele, Robin Le Mestre, and Ignazio Maria Viola, "Morphing blades for tidal turbines: A theoretical study," *Renewable Energy*, vol. 183, pp. 802–819, 2022
[2] Herath, Manudha T. et al., "Hydrodynamic response of a passive shape-adaptive composite hydrofoil," *Marine Structures*, vol. 80, p. 103084, 2021
[3] Somoza, María Hernández, Terence Macquart, and Alireza Maheri, "Reduction of tidal turbines hydrodynamic loads employing bend-twist adaptive blades," presented at the 3rd International Symposium on Environmentally Friendly Energies and Applications (EFEA), IEEE, 2014, pp. 1–5.

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