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PSO-Based Framework for Preliminary Jacket Substructure Design in Offshore Wind Applications

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ABSTRACT

Offshore wind energy plays a crucial role in expanding global renewable energy sources, offering higher generation capacity compared to onshore wind due to the superior quality of wind resources available offshore [1]. To access these resources, wind turbines are being installed farther from the coast, where water depths are greater [2]. In these settings, jacket-type support structures for seabed-fixed offshore wind turbines present advantages over alternatives such as monopiles. The design, sizing, and analysis of these structures is a complex process influenced by factors such as site assessment, load evaluation, and design optimization.

This study proposes a methodology for the autonomous design of jacket-type substructures, generating preliminary designs with the required level of detail for the initial design phase. The methodology ensures compliance with a wide subset of the main structural requirements established by international safety standards and recommendations, including section capacity, buckling, resonance, and joint geometry. To achieve this, the Particle Swarm Optimization (PSO) algorithm [3] is used as a search and optimization model. The PSO is coupled with a Finite Element structural Model to obtain the jacket structural response and the evaluation of the imposed requirements. The initial swarm population is calculated in a non-random computationally efficient manner, following the simplified formulation procedure proposed by Jalbi and Bhattacharya [4], considering configurations with 3, 4, and 5 legs and varying bay sections. The proposed strategy integrates turbine characteristics with the environmental properties and site conditions of the jacket's location. It is found that precomputed initial populations allow to reach much better results than random initial populations, not only in terms of achieving optimal results but also in enhancing the robustness of the algorithm by increasing the likelihood of finding feasible and optimized solutions.

References

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