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Topology Optimization of a Jacket Structure for an Offshore Wind Turbine with a Genetic Algorithm

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Abstract

Structural optimization of support structures for wind turbines is complicated by the need to assess fatigue damage. An offshore wind turbine is a very dynamic and complex system, and due to nonlinearities in the rotor loads this situation calls for transient time-domain simulations, with combined wind and wave action [1].

Most existing methods for structural optimization are based on maximizing stiffness, using one or more static loadcases, whereas the problem here has to take fatigue constraints into account. This is difficult with gradient-based algorithms [2] and no optimality theory exists. The current state of the art of support structure optimization is therefore the use of heuristics such as genetic algorithms [3].

The structural model considered here is a jacket consisting only of beam elements that is subject to one 90 second operational loadcase from which the fatigue constraint is evaluated. Symmetry was used both in order to reduce the number of design variables as well as increase the robustness of the solution. The optimization was performed with a genetic algorithm using a small population of 16 designs. Under a ground structure approach, the structure was initially modeled with a large set of beams. Beams were sized in an iterative manner, and beams under a certain minimum size were removed. The objective function includes a term proportional to the number of elements which represents the cost of welding and painting the beams, and thereby favors less structural elements.

Results show that it is possible to obtain reasonable structures with this approach, similar to what would be obtained by straightforward manual optimization, but often with a lower weight. Due to the many simplifications the final designs are not completely realistic, but this study highlights the important issues that do arise and is a first step toward more comprehensive automatic design optimization.

References

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