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Abstract

Optimization and reliability design of a floating offshore wind turbine

The floating wind turbine technologies currently under development must be designed to withstand environmental conditions for several decades, taking into account several uncertainties on the solicitations and the models. According to design standards, the validation of a configuration must satisfy in particular both extreme limit state and fatigue limit state. A reduction of the cost of electricity generated by these turbines is required to become comparable with other sources of power generation, thus motivating optimization of the configuration.
Both the evaluation of the reliability constraints, and a fortiori the optimization submitted to these constraints, constitute a challenge because of the considerable computation cost. This cost results from the complexity of the aero-hydro-servo-dynamic simulators as well as from the very large number of load cases prescribed by the design standards. After introducing the problem, we present several strategies to limit this cost calculation. The calculation of the constraints in extreme limit state can be simplified by describing the input signal of the loading (swell, wind) by harmonics with a hundred random variables. Assuming the load process to be stationary, we recover a time independent reliability problem. The computation of the most probable point at an arbitrary time, greater than initial transient stage, enables to determine the critical loading with reduced simulation times when compared to standards. The outcrossing rate can be calculated with a limited cost in a FORM framework or more precisely with dimension reduction strategies. Results are illustrated for the case of a mast of a wind turbine. The calculation of fatigue stresses can be considerably accelerated by constructing a response surface based on an optimal experimental design. In the case of optimization, we illustrate the interest of a non-derivative algorithm (SQA), developed at IFPEN, which is particularly adapted to this type of simulator, with the application to the configuration of an electrical cable connecting floating wind turbines. Finally, we propose lines of thought to decouple the optimization loop from the calculation configuration of the reliability constraints. This last point is addressed in a thesis to optimize the configuration of the mooring lines for a floating wind turbine.

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