Fluid-structure interaction analysis of a floating wind turbine

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ABSTRACT

Floating offshore wind turbines (OWTs) have evolved as an attractive alternative to conventional fixed-foundation turbines, which are limited to on- or near-shore areas. Floating OWTs, in contrast, can be installed in greater water depths to harvest the stronger and more steadily blowing wind far away from the coast. However, they may also experience significantly higher hydrodynamic forces and accelerations due to their motion in the seaway. In order to ensure their structural integrity, it is essential to take the fluid-structure interaction (FSI) into account to analyse the impact of the aero- and hydrodynamic forces on the motion behaviour of the structure and the resulting deformations and stresses inside. In the scope of the subproject "Fluid-structure interaction and optimization of a floating platform for offshore wind turbines" (FSIOpt) within the joint project HyStOH, we simulate the FSI of a fully weather-vaning 6 MW downwind turbine [1]. We employ a partitioned solution approach, where the aero- and hydrodynamic problem and the structural problem are solved separately and are coupled by iteratively exchanging and updating boundary conditions within a time step until an equilibrium is reached. Due to separate treatment of the subproblems, it is possible to employ different spatial and temporal discretization schemes as well as already existing specialized and particularly fast solvers for their numerical solution. Consequently, the partitioned approach is not only very flexible but also allows for an efficient solution of FSI and other strongly-coupled multifield problems [2, 3]. The OWT structure can be modelled as rigid or elastic, depending on whether only the global motion behaviour or the deformations and internal stresses are of interest. This way, the computational cost can be easily adjusted to match the objective of the simulation. In order to enable the use of a detailed FE model in the FSI simulation of the OWT, a method known as substructuring is used to reduce the number of degrees of freedom within the coupled simulation. Afterwards, in the post-processing, the results can be restored for all degrees of freedom and a detailed stress analysis can be performed.

REFERENCES

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