FLUID-STRUCTURE INTERACTION WITH CONTROLS FOR WIND TURBINE SIMULATION USING A NOVEL CO-SIMULATION APPROACH

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ABSTRACT

Renewable and clean energy methods are increasingly becoming more popular as our fossil fuels diminish and more environmentally friendly methods are sought. Wind energy harvesting with wind turbines is such a renewable energy source gaining widespread popularity. More effective wind turbines are being designed, with the next generation wind turbines having blade lengths exceeding 100 m. This poses many challenges in the design and operations of these structures. Scalable multiphysics simulation tools are required in order to design and judge performance, durability and safety of these machines.

We present a simulation of a wind turbine involving the interaction of the generator/gearbox, flexible composite blades, control unit and the three-dimensional flow field. We employ the co-simulation approach by coupling four codes; abaqus/standard modeling the tower and composite blades, openfoam modeling the air flow around the structure, an in-house multibody dynamics code modeling the generator, and matlab modeling the control unit. In contrast to contemporary fluid-structure interaction of wind turbines, the rotational velocity of the turbine is the result of the fluid-structure-signal coupling and does not need to be prescribed in the presented approach resulting in a more physical representation.

First we perform a fluid-structure simulation comparing results against measurement data from the national renewable energy laboratory (nrel) unsteady aerodynamic experiment phase vi performed in the nasa ames wind tunnel to validate our models. Next we extended the simulation to a fully coupled fluid-structure-signal interaction for modeling an emergency brake maneuver scenario in order to protect the turbine from self-destruction.

For this loading scenario it is essential to model the control system taking into account the interaction of the turbine components with the environment (air flow).

A novel co-simulation algorithm is used that guarantees both accuracy and stability, and captures the realistic behavior by appropriately modeling the interaction of various components. One of the advantages of the co-simulation

approach is that it allows combining different fidelity models during the various design and development stages, thus helping to improve technical system evaluation at every stage of the design process.