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Dynamic Two-Way FSI Simulation for a Blade of a Small Wind Turbine

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Abstract : An optimal wind turbine blade design must be able of capturing as much energy as possible from the wind source available at the area of interest. Many times, an optimal design means the use of large quantities of material and complicated processes that make the wind turbine more expensive, and therefore, less cost-effective. For the construction and installation of a wind turbine, the blades may cost up to 20% of the outline pricing, and become more important due to they are part of the rotor system that is in charge of transmitting the energy from the wind to the power train, and where the static and dynamic design loads for the whole wind turbine are produced. The aim of this work is the develop of a blade fluid-structure interaction (FSI) simulation that allows the identification of the major damage zones during the normal production situation, and thus better decisions for design and optimization can be taken. The simulation is a dynamic case, since we have a time-history wind velocity as inlet condition instead of a constant wind velocity. The process begins with the free-use software NuMAD (NREL), to model the blade and assign material properties to the blade, then the 3D model is exported to ANSYS Workbench platform where before setting the FSI system, a modal analysis is made for identification of natural frequencies and modal shapes. FSI analysis is carried out with the two-way technic which begins with a CFD simulation to obtain the pressure distribution on the blade surface, then these results are used as boundary condition for the FEA simulation to obtain the deformation levels for the first time-step. For the second time-step, CFD simulation is reconfigured automatically with the next time-step inlet wind velocity and the deformation results from the previous time-step. The analysis continues the iterative cycle solving time-step by time-step until the entire load case is completed. This work is part of a set of projects that are managed by a national consortium called “CEMIE-Eólico” (Mexican Center in Wind Energy Research), created for strengthen technological and scientific capacities, the promotion of creation of specialized human resources, and to link the academic with private sector in national territory. The analysis belongs to the design of a rotor system for a 5 kW wind turbine design thought to be installed at the Isthmus of Tehuantepec, Oaxaca, Mexico.

Keywords : blade, dynamic, fsi, wind turbine
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