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MESH DEFORMATION TOOL FOR OFFSHORE WIND TURBINES FLUID-STRUCTURE INTERACTION

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Strong dynamical effects are expected during the whole life cycle of Offshore Wind Turbines (OWTs). The combination of this violent loading scenario and the slenderness of rotor blades requires considering Fluid-Structure Interaction (FSI) effects at the design stage.

Industry standards for OWT aerodynamic loads computations are based on simplified engineering models (A.Heege et al 2013 and J.M.Jonkman et al 2007). Even if these numerical approaches are less computationally demanding, three-dimensional flow effects are just estimated based on empirical corrections. Hence, the development of more sophisticated CFD techniques for the detailed design of the rotor is justified (as stated by Y.Li et al 2012).

To account for FSI phenomena, the discretized fluid domain needs to be readapted to structural deformations, motivating the implementation of *mesh deformation algorithms*. We have developed a mesh deformation tool based on the original formulation of the *elastic analogy* described by A.de Boer (2008). The performances of the implemented methodology are compared with other approaches, such as the *Laplacian smoothing* or the *Winslow smoothing*. Special attention was paid to the deformation of complex meshes including tens of million points.

To illustrate the performances of the developed solution in the framework of a complete FSI simulation, the DTU 10-MW Reference Wind Turbine (C.Bak et al 2013) was studied. All presented simulations were performed with the help of the commercial CFD package FINE^{TM}/Turbo (NUMECA International 2013). As a first approach, in order to focus on the study of rotor aeroelastic effects, no hydrodynamic loads were considered. The unsteady effects due to blade passage were also neglected; hence the tower was not modelled in this preliminary analysis. A reduced-order model (ROM) was chosen for the structure, described by its mode shapes and natural frequencies. Steady FSI simulations at different operating points were performed, in order to quantify the expected deformations of the rotor.

Figure 1 exemplifies the capabilities of the developed deformation tool when dealing with big structural displacements. In this case a 15 degrees pitch rotation has been imposed to the 24.1% relative thickness FFA-w3-241 airfoil, which is equipped by the DTU 10-MW wind turbine at blade tip. Both original geometry and resulting deformed mesh are superposed for illustrating purposes.

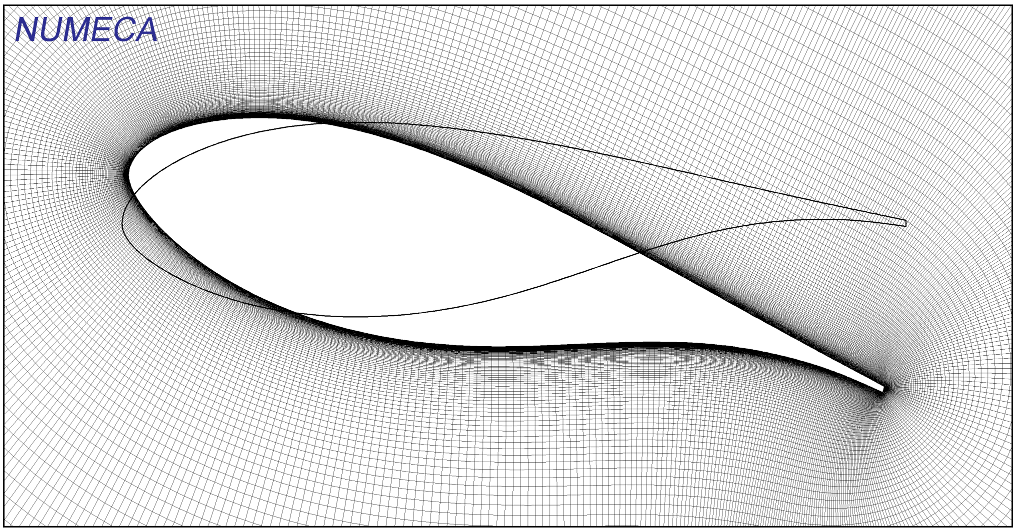

Figure 1: Mesh deformation for an imposed pitch rotation on DTU 10-MW blade tip

Future works will be devoted to extend the capabilities of the developed methodology to account for hydrodynamic excitations on bottom-fixed and floating OWT configurations.

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REFERENCES

[1] A.Heege, A.Gaull, S.G.Horcas, P.Bonnet, M.Defourny (2013), *Experiences in controller adaptations of floating wind turbines through advanced numerical simulations*. AWEA Wind Power Conference. Chicago

[2] J.M.Jonkman, M.L.Buhl Jr. (2007), *Development and Verification of a Fully Coupled Simulator for Offshore Wind Turbines*. National Renewable Energy Laboratory (NREL), Conference paper 500-40979

[3] Y.Li, K.Paik, T.Xing, P.M.Carrica (2012), *Dynamic overset CFD Simulations of wind turbine aerodynamics*. Renewable Energy, an International Journal. Vol 37, Issue 1:285-289

[4] A. de Boer (2008), *Computational fluid-structure interaction, Spatial coupling, coupling shell and mesh deformation*. PhD Thesis, TU Delft

[5] C.Bak, F.Zahle, R.Bitsche, T.Kim, A.Yde, L.C.Henriksen, M.H.Hansen, J.P.A.A.Blasques, M.Gaunaa, A.Natarajan (2013), *The DTU 10-MW Reference Wind Turbine*. Danish Wind Power Research 2013, Fredericia, Denmark

[6] NUMECA International (2013), *FINE^{TM}/Turbo v9.0 User Manual*. April 2013