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EVALUATION OF AERODYNAMIC LOADS PREDICTION ON WIND TURBINE BLADES

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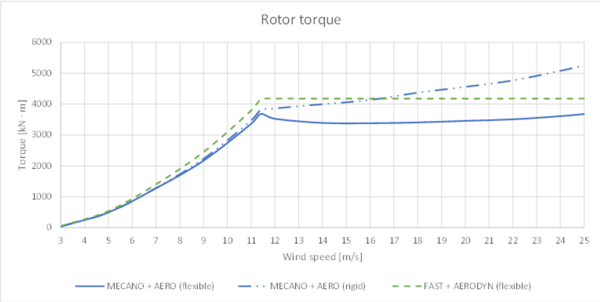
SUMMARY

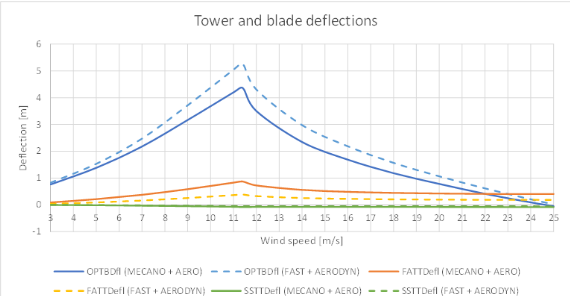
In the present report it has been studied the aerodynamic loads and deformations of the NREL 5-MW and SWT 2.3-93 wind turbines obtained with the flexible multibody dynamic *SAMCEF/MECANO* solver coupled with two different aerodynamic methods: the Blade Element Momentum method implemented in a *SAMCEF* module called *AERO*, and a 3D panel method implemented in the open source software *Vortexje*. The main purpose is to compare the results obtained with both methods in terms of efficiency and accuracy in order to see their validity and limitations. Other purpose is to study the influence of blade deformations, for which simulations have been carried out considering rigid and flexible blades. The last purpose is to study the influence of gravity loads and flow asymmetries introduced by shaft tilt and yaw angles.

To demonstrate the validity of the *MECANO + AERO* method, the steady-state response for an axial, steady and uniform wind and without gravity loads has been compared with simulations run with *FAST + AeroDyn + BeamDyn*, based on the BEM theory as well. The results obtained in terms of rotor thrust and torque and blade deformations show similarity between them and show a clear influence of the blade deformations on the rotor performances. Subsequently, the dynamic response with *MECANO + AERO* and *MECANO + Vortexje* at the rated operating point has been studied. The results obtained, in terms of loads and deformations, show some differences between both methods. Comparing them with CFD results of other authors, some results seem to be better predicted by BEM method and other by the panel method. After that it has been studied the influence of the tilt and yaw angle under gravitational loads at the rated operating point with *MECANO + Vortexje*. This influence shows a clear unsteady periodic response in deformations and loads which must be taken into account to predict fatigue loads. Finally, it is compared the efficiency of both methods. The CPU time required by *MECANO + AERO* is much less than by *MECANO + Vortexje* to reach convergence of results. In order to reduce the time required by *MECANO + Vortexje* it has been studied the effect on the CPU time and rotor thrust and torque of deleting the last wake layer after different rotor revolutions.

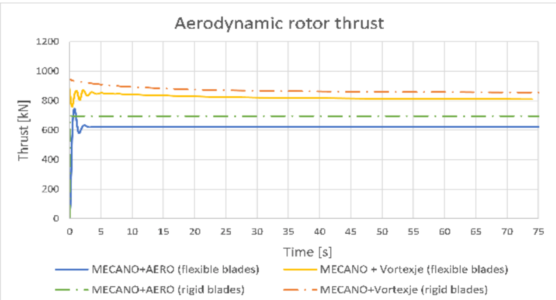
The main conclusion is that *MECANO +AERO* method is appropriate for uniform and steady flows in terms of efficiency and accuracy making its use more convenient than *MECANO + Vortexje*. However, it is inevitable that in actual operating conditions the wind direction changes, causing that wind turbines operate at yaw angles producing a skewed wake. Due to inability of *MECANO + AERO* to correctly predict these effects, in general it would be more convenient to use *MECANO + Vortexje* adding some improvements, such as flow separation and rotational effects.



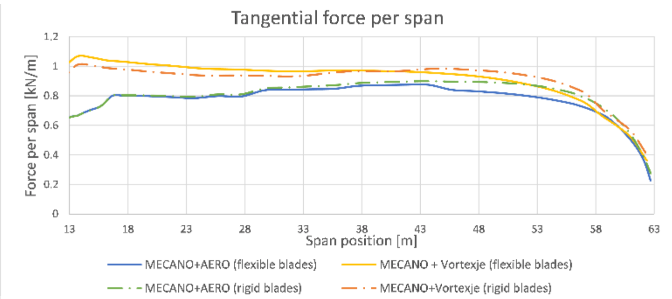
Steady-state response of the rotor torque as a function of wind speed (NREL 5-MW)



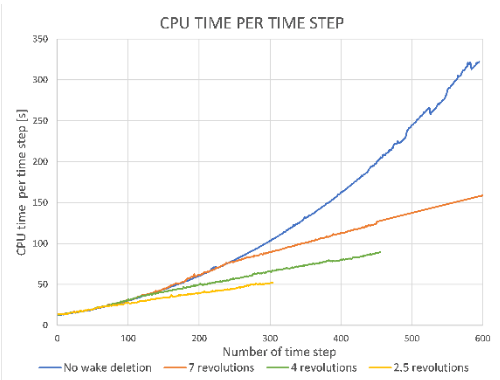
Steady-state response of the tower and blade deflections as a function of wind speed (NREL 5-MW)



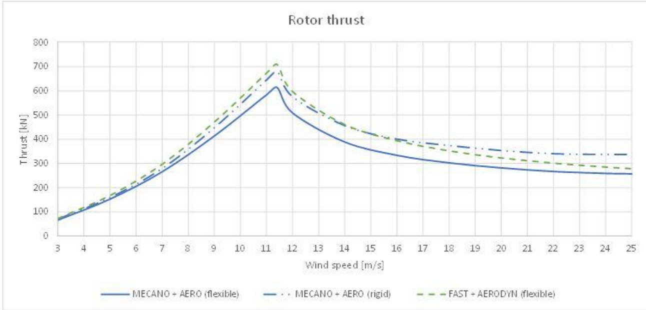
Dynamic response of the aerodynamic rotor thrust (NREL 5-MW)



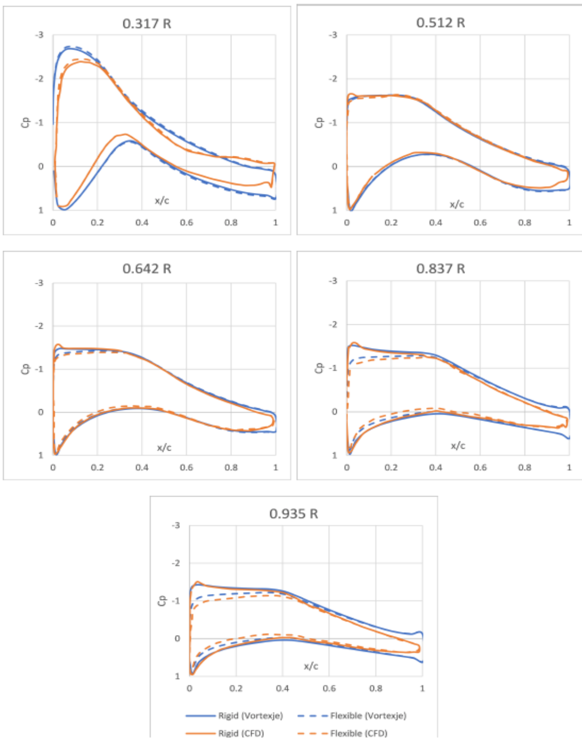
Distribution of tangential force per span (NREL 5-MW)



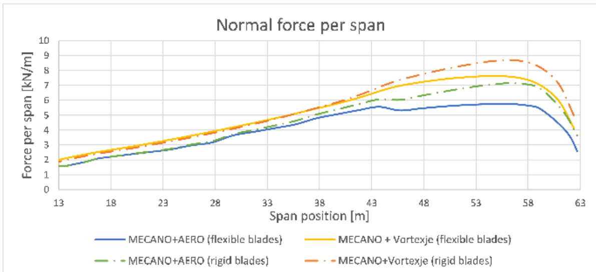
Required CPU time for each new time step with last wake layer deletion (NREL 5-MW)



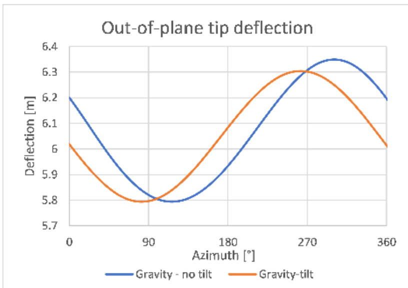
Steady-state response of the rotor thrust as a function of wind speed (NREL 5-MW)



Pressure coefficient along the chord in different blade span sections (NREL 5-MW)



Distribution of normal force per span (NREL 5-MW)



Out-of-plane tip deflection under gravity loads and shaft tilt (NREL 5-MW)