Advanced Dynamical Sub Models for more precise Load Calculations of WTGs

PO.176

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Abstract

Load simulation is a crucial part in the product development process of wind turbine generators (WTG). While the necessary design load cases (DLC) are defined by guidelines, e.g. IEC 61400-1 (Ed.3), the model approach representing the dynamical behavior of the WTG is almost unconstrained. As hub height and rotor diameter of WTGs are continuously increasing, the turbines are more and more prone to vibrations caused by turbulent inflow, wind shear, rotor imbalance, etc. To cover this load driving behavior correctly in load simulations, advanced dynamical model approaches are required. This leads to an increase of the numerical complexity driving the total simulation time needed to finish the large number of DLCs determined by the guidelines like IEC 61400-1 (Ed.3).

The study at hand shows examples (e.g. rotor blade, pitch system and azimuth system) how the compromise between accuracy and numerical efficiency could be achieved. For the validation of each of these sub models, thorough measurements have been carried out showing good correspondence to the simulation results. The modelling and the simulation have been done using the multi-body software alaska/Wind. Using a high performance solver reasonable computation times may be achieved for detailed models.

Objectives

Increased design requirements for turbine development call for more detailed models in design and load calculation, three crucial models blade(1), azimuth system(2), pitch system(3) are:

- Modelling of non-linear blade structure enabling bent-twist coupling (1)
- Modelling of torque limitation and of turbine operation procedures (brake and motor control) for the azimuth system (2)
- Modelling of torque limitation and of dynamic behavior including position control for the pitch system (3)
- Comparison of all improved models to existing models and validation with measurement data (1, 2, 3)

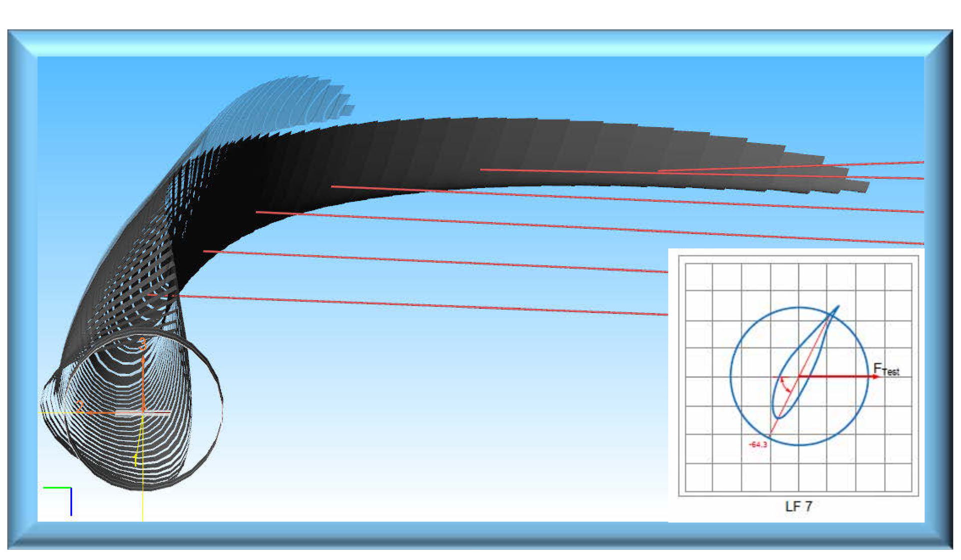
Methods

(1) **Blades:** Accurate models for blades
- Non-linear beams (using implicit solver)
- Beam models with bent-twist coupling
- Linearized models for fast calculations
- Validation with ANSYS and static bending test at test rig

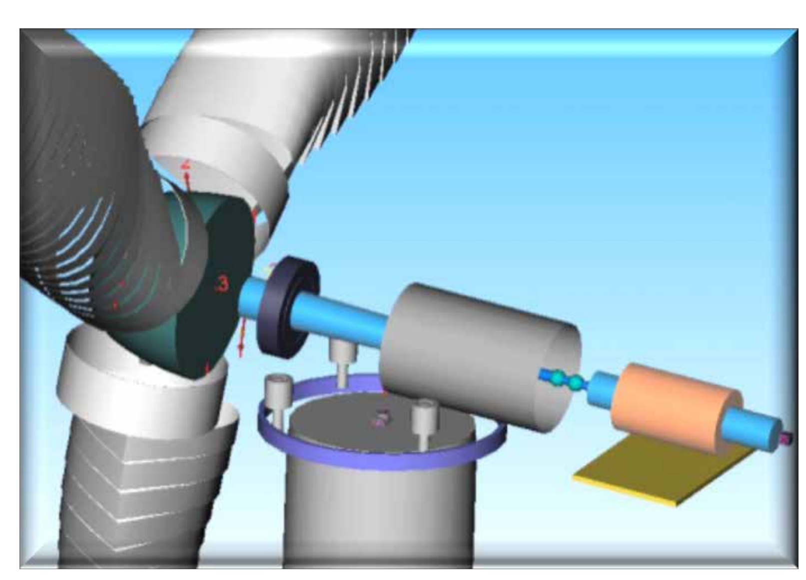
(2) **Azimuth system:** Detailed model considering:
- Brake mechanisms and friction
- Torque based interaction of drive and nacelle
- Procedures of turbine operation
- Validation with drive measurements at test rig and with measured field data

(3) **Pitch system:** Detailed model considering:
- Bearing friction, position controller
- Torque based interaction of drive and blade
- Procedures of turbine operation
- Validation with drive measurements and field data

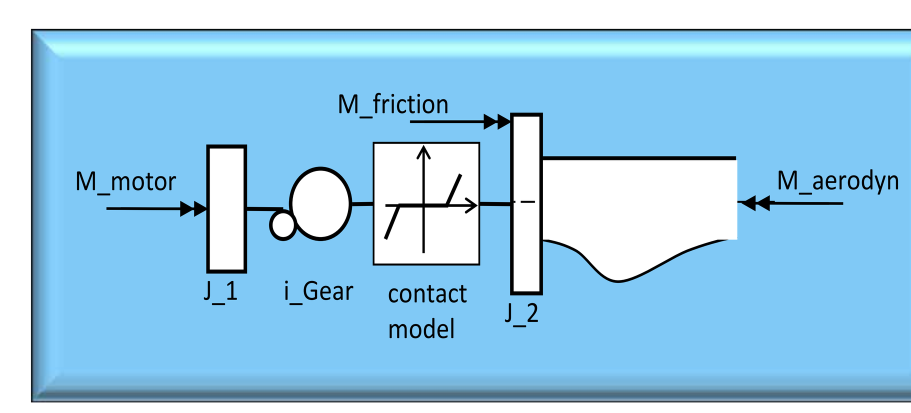
Model



alaska/Wind FE-model for undeformed and deformed rotor blade with static loading

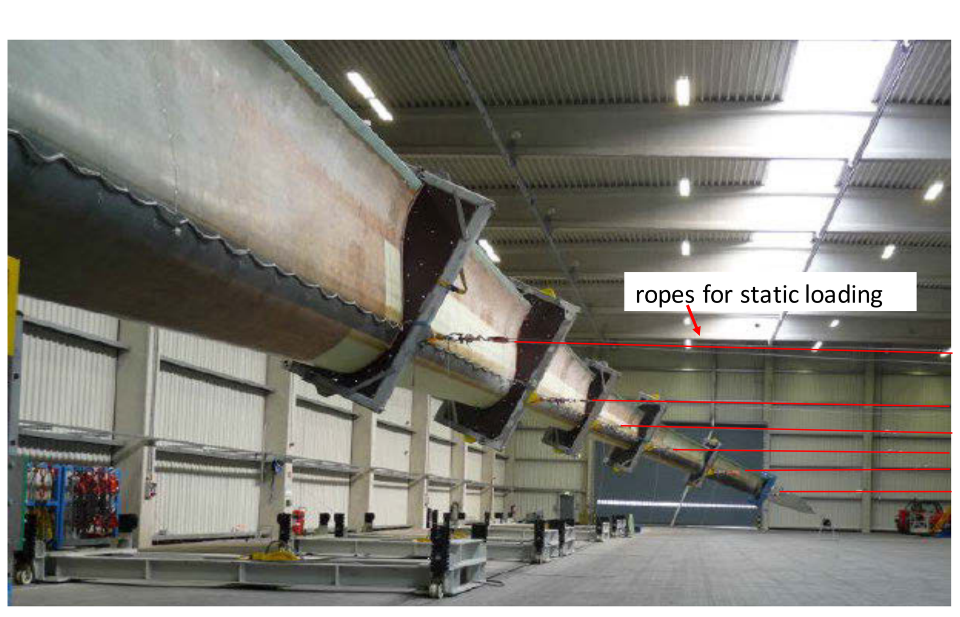


alaska/Wind model including multiple yaw drives



Block model diagram for the pitch system implemented in *alaska* and *MatlabSimulink*

Validation

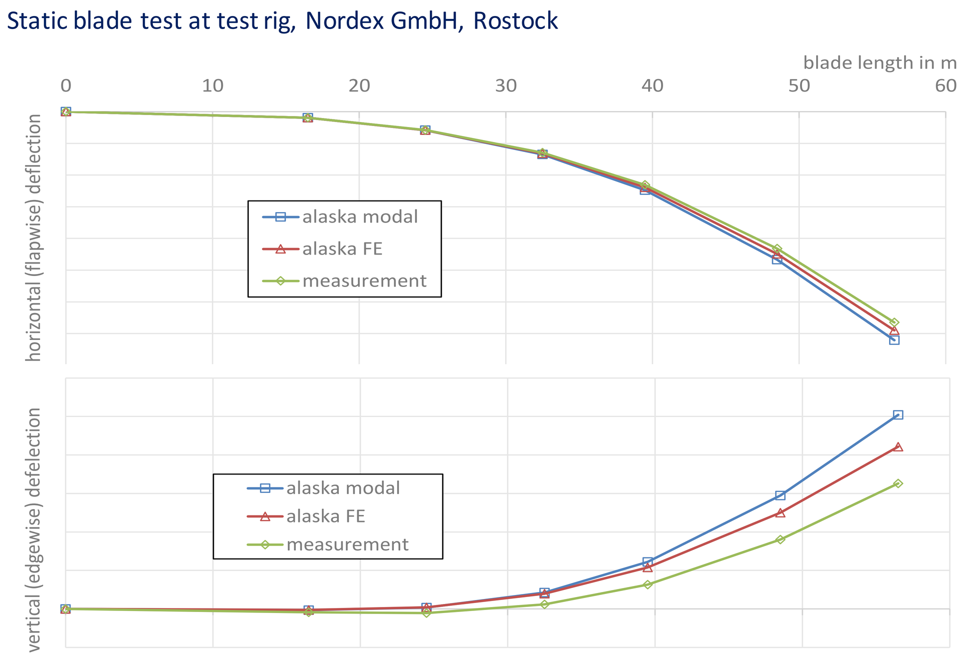


Static blade test at test rig, Nordex GmbH, Rostock

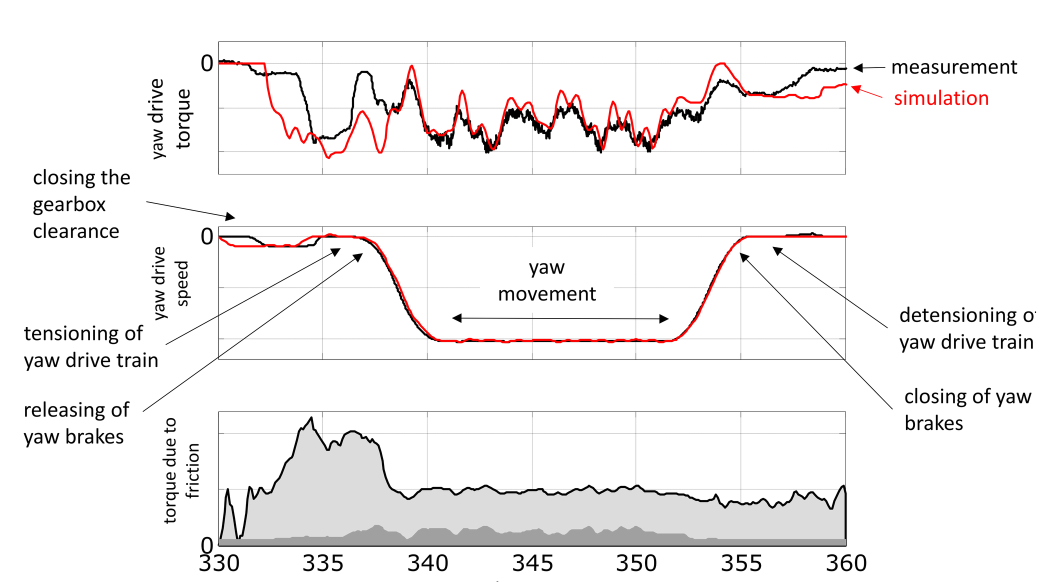
Yaw drives and load machines at test rig, Nordex GmbH, Rostock

Blade connection test rig, Nordex GmbH, Rostock

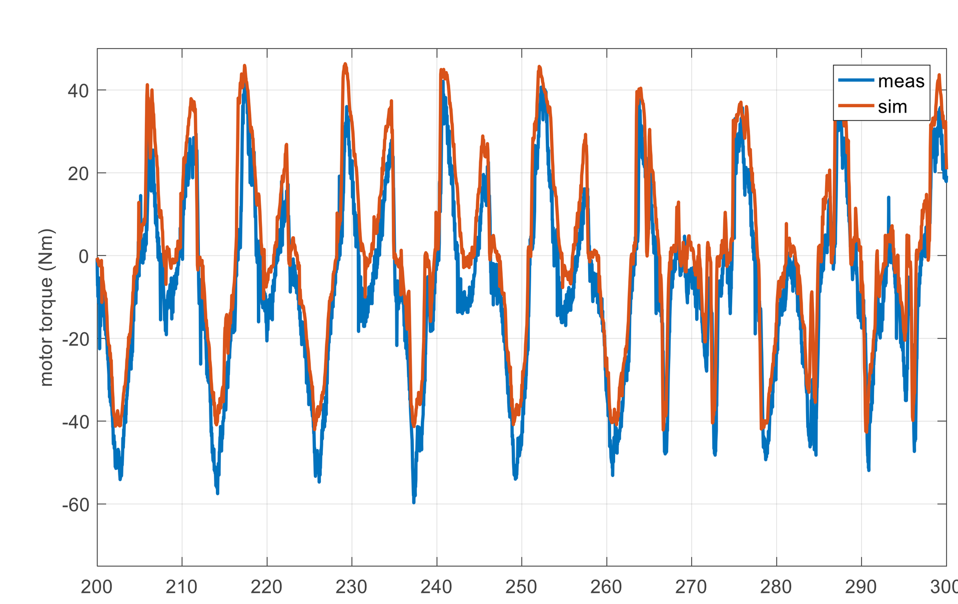
Results



Comparison of blade deflections from differents models and test results



Comparison of time series for detailed azimuth system, model and field measurements for procedure of yaw start, yaw movement, yaw stop



Comparison of simulated and measured time series for the pitch system model

Conclusions

- Successful implementation of improved models for three crucial turbine parts: blade azimuth and pitch system
- Reasonable Increase of computation times
- Successful validation of models
- Reproduction of more realistic dynamic behavior for blade vibrations and pitch motion profile
- More realistic representation of turbine operations for azimuth braking and moving procedures
- Improved analysis of drive motors

References

1. SÜNKEL, Jörn: Implementation and Validation of a Dynamic Friction Model for Modelling of a Wind Turbine's Yaw Motion in Multibody Simulation, *master's thesis, Nordex Energy GmbH, 2016*

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