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Electromechanical interactions in wind turbines of high nominal power

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1 Motivation

The demand for increasing nominal power in wind energy leads - especially in gear-less systems - to significantly increasing generator dimensions. The only way to realise the increased dimensions is by using lightweight construction methods. This often leads to a reduction of the component's stiffness, which requires a more intensive consideration of the structural dynamics [1]. This is in particular true since the wind turbine exposes the generator to a more complex excitation compared to conventional power plants. The main reason for this complexity is the turbulent, fast varying and stochastic wind. It leads to a loading on the main shaft that result in bending moments for the generator as shown in fig. 1. Research shows that the stochastic loading of the turbines can, under certain circumstances, lead to resonances in the generator (see [2][3]). The aforementioned research focuses on the one-way influence of the turbine structure on the generator.
Although, in general two-way coupling effects in wind turbines can be of significant importance for the calculated load levels [4], the specific impact of the generator to the turbine has not been investigated yet. The influence on short-term load levels leads to the assumption that the calculated operational lifetime based on fatigue can also be affected. Additionally, the sensitivity of the design choices on the loading through this two-way electro-mechanical coupling is still unknown. Furthermore, using simulation based analysis methods, the results strongly depend on the chosen model fidelity as [5] and [6] showed. The previous mentioned aspects show the possible industrial but also scientific value of focusing on the modelling and sensitivity analysis of the generator-turbine interaction.

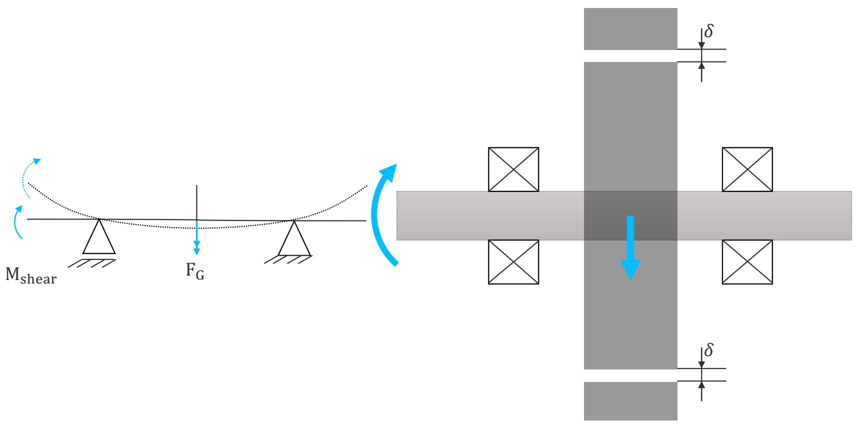

Figure 1: Illustration of the complex load situation in wind turbines

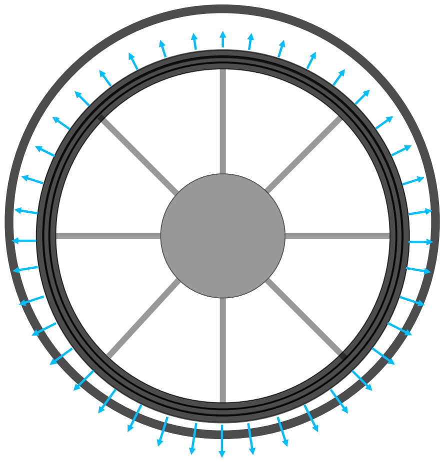

Figure 2: Magnetic force dependent on the air gap length

2 Research Scope

The aim of this research is to be able to simulate vibrational interactions between the generator magnetic field and the turbine as a two-way coupling. The two-way coupling is of importance as the magnetic force increases with a smaller air gap as shown in fig. 2. This reciprocal dependency means that any displacement of the generator rotor due to the aforementioned bending moments is further increased by the magnetic forces. Therefore, the global loading may increase. Using the two-way coupling the effect on the operational lifetime is analysed in combination with design dependencies and modelling fidelity. As a result, the minimum model fidelity required to calculate the operational lifetime of the turbine under consideration of the generator dynamic behaviour will be identified. This offers the possibility of adapting the generator design in future more closely to the turbine's requirements. At the same time, a better exploitation of the scope for design becomes possible, which promises a higher reliability of the generator and the wind turbine as well as a more cost-efficient design of the overall system.

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