Project: Testing of Large Offshore Wind Turbine Blades

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Background

As wind turbine blades have become longer and more compliant, the ability to predict blade twisting has become more important. The structural twisting, or torsion, of blades has a significant impact on loadings, power production and aero-elastic stability. It is, therefore, critical that the torsional response of blades is well understood and captured within the numerical analysis tools used for wind turbine design. Currently there are no requirements under the IEC design standards to verify the torsional stiffness of blades. Furthermore, there are numerous well documented issues concerning the numerical prediction and manufacturing impact on the torsional characteristics of blades. Currently, blade manufacturers have limited opportunities to validate their models and as a result may restrict their innovation to address the uncertainty in the torsional response of a blade.

No facilities in the world currently exist to test blades beyond 100m long - testing of future blades which exceed this length will therefore be problematic. Longer blades take longer to instrument, place higher demands on test equipment and prove more challenging to replicate the target bending moment distributions required for the current certification tests. As a result, test campaigns for large offshore blades typically take around a year to conduct and are very expensive. Having to wait a year to affirm that a given design is acceptable poses a barrier to innovation and will only worsen as blade length increases for the current certification test approach.

Project description

My research aims to design a test rig and conduct a series of tests on a full-scale blade that can be used to verify its torsional characteristics. The measurements taken from the tests can be used to inform best modelling practice when numerically analysing the torsional response of the blade.

The future IEC 61400-23 Rotor Blade Test Standard will allow for segmented composite blade testing (blade sections at full scale are tested, but the full blade is not tested in one piece). Segmented testing could be one potential means of overcoming the current issues with testing large offshore blades as a single piece, but has not yet been implemented in the testing and certification of any wind turbine blades. This research will explore the practicalities of implementing this approach based on current and future large offshore wind turbine blades.

Currently, the technological breakthroughs of the research are somewhat speculative. It is hoped that through the course of the EngD a methodology will be developed to enable physical testing of a blade to verify the torsional characteristics. This will involve designing of the test equipment and setup but also detailing the complimentary numerical analysis required to verify the measurement data.

The second objective is to outline the requirements to test a blade in sections rather than as a single piece. It is hoped that by the end of the EngD the requirements for sectional blades will be detailed, including details of the experimental setup, consideration of the boundary conditions on the test, and any manufacturing requirements for blade sectional testing.

Research outcomes/impact

The torsional testing will enable the industry to have much greater confidence in their design and analysis tools in predicting the torsional response of blades. The research will provide a framework where blade manufacturers can verify the torsional properties of the blade, something which is not currently done or stipulated in the IEC standards. Whilst in the short term the blade test programme may become more expensive as a result of performing torsional tests, in the long term, it is envisaged that the understanding and knowledge developed through the torsional test programme will help optimise the design of future blades so that there is a greater likelihood they perform as expected.

Sectional blade testing could potentially reduce the overall length and cost of a certification test programme. Smaller blade sections can be tested in a greater number of facilities, potentially running tests in parallel, applying loading to the blade that more closely represent the loading it would experience in reality and making measurement of the blade response less time-consuming and with greater resolution. Manufacturers would be given greater freedom to innovate if the length of the test programme were reduced - something that is currently difficult to justify when test programs take a year to perform.

Project Sponsorship:

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