Full-scale structural testing at DTU Large Scale Facility

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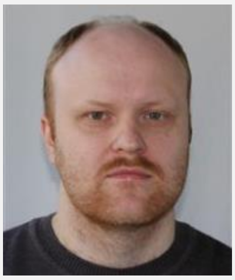
Kim Branner is senior research scientist at DTU Wind Energy. He is heading the Structural Design & Testing team as well as DTU Large Scale Facility, which is a unique research test facility for studying strength and fatigue of large structures exposed to complex loading.



Sergey Semenov is development engineer at DTU Wind Energy. He is mainly focused on implementing algorithms for post processing experimental data and using these results for the comprehensive test controlling.

Introduction

Full-scale testing is essential because it is the only type of testing which reveals the reliability of methods for analysis and design. Thus, full-scale tests quantify the model uncertainty – an essential element in the overall structural reliability assessment. Further, since this type of testing reveals the full complexity in response and failure of real structures, full-scale testing is invaluable in the fundamental research of developing methods for structural simulation, analysis and design, both with respect to structural and material behaviour. This is what the aim is for the new DTU Large Scale Facility.

DTU Large Scale Facility

DTU Large Scale Facility consists of a 1560 m^2 test hall with three test stands capable of testing 45 m, 25 m and 15 m blades or other slender structures. Inside the test hall, a 460 m^2 staff building is constructed. The staff building is two stories high and contains the control room, workshop, depots, visitor centre and various service facilities. The three test stands are designed to withstand the highest static loads in the vertical direction. Fatigue loads can be applied in any direction. The floor has built-in rails, which makes it flexible to apply loads where needed.

The actuators applying loads to the structures tested are powered by a 5-pump Hydraulic Power Unit with a total capacity of 500 lpm at 280 bars and is prepared for extension with an additional pump to a total capacity of 600 lpm.

The hard line is split into 3 independent pressure lines, one for each test stand and thus any interaction between tests is prevented. The system is configured to select up to a maximum of 6 pump sets to the 45 m Test Stand, and 4 pumps sets to the 25 m and 15 m Test Stands. It is possible run the hard lines at different pressures simultaneously.

The controller supplied by MOOG is used for controlling movements of all actuators according to the test program. 3 Gantner Q-stations are used for data acquisition from different types of sensors mounted on the blade (strain gauges, accelerometers, etc.). All measurements are synchronised via NTP based timestamping.

For comprehensive control of the test (adjusting loading parameters according to measured strains and target moment curves, block loading for achieving target total damages in all controlled points, etc.) a top level controlling system is implemented (see Figure 1) using LabVIEW software as well as MOOG and Gantner SDKs.

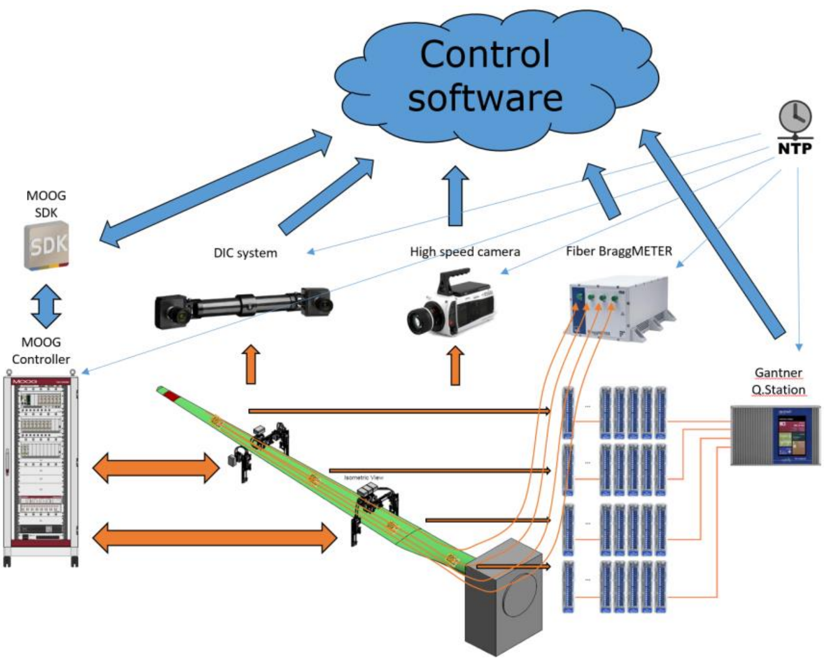


Figure 1. Interfacing schema

Other measurement systems (fiber Bragg meters, digital image correlation measurement system, acoustic emission measurement system etc.) can be interfaced with the top level controlling system. See also [1].

Blade tests

As part of moving the DTU Large Scale Facility from commissioning into operation, a number of Site Acceptance Tests (SAT) will be performed at the facility. The first tests will focus on static testing and fatigue testing of 14.3 m Olsen Wings wind turbine blades.
The static testing is performed using up to six hydraulic winches (stacked by two in three frames) and a system of snatch blocks and ropes (see Figure 2). The test is controlled by the MOOG controller and the strains are measured by strain gauges mounted on the blade and recorded by Gantner controller.

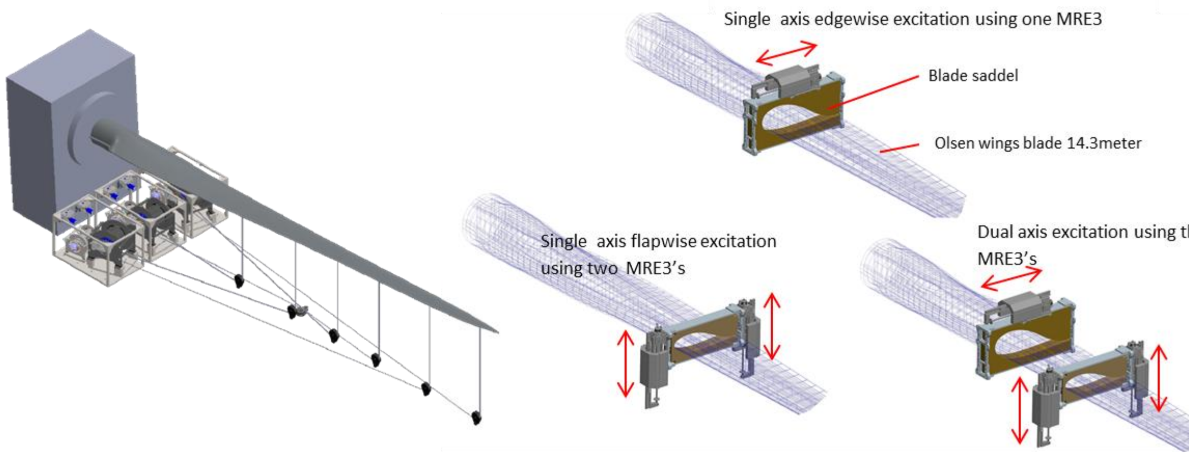


Figure 2. Layout for static testing and fatigue testing

The fatigue testing is performed using mass resonant exciters (MREs) mounted on the blade. The SAT of the MREs will be performed to evaluate the design of the exciters, and it will consist firstly of single axis dynamic loading in flapwise and edgewise direction separately, and secondly of dynamic loading in flap and edge simultaneous, also known as dual axis fatigue testing. See Figure 2.
In the EUDP project Blatigue one of the blades will also be subjected to the complete testing program which normally is performed to certify blades [2], this includes: Static testing to max design loads and single axis fatigue testing in flapwise and edgewise direction separately (2 million cycles). Tuning masses will be applied to meet the target bending moment curve along the span of blade. Again the tests are controlled by the MOOG controller and the strains are measured by strain gauges mounted on the blade and recorded by Gantner controller.

The fatigue target curves are computed within the Blatigue project utilizing the aeroelastic code HAWC2. Simulation of the tests was done before running the test using an in-house developed software based on the HAWC2 software. This software makes it possible to fine tune the setup with exciters and tuning masses. This tool is presented in another ISMEM 2017 paper by Belloni and Berring [3].

Acknowledgments

This research will be conducted using mechanical testing equipment from Villum Center for Advanced Structural and Material Testing (CASMaT), Grant No. VKR023193 from the Villum Fonden.

References

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[2] IEC 61400-23. Wind turbines - Part 23: Full-scale structural testing of rotor blades. Edition 1.0, 2014-04-08, TC/SC 88, IEC, Geneva, Switzerland.

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