Rotor Blade Shell Test Bench
Focus Area Project: ManuFact

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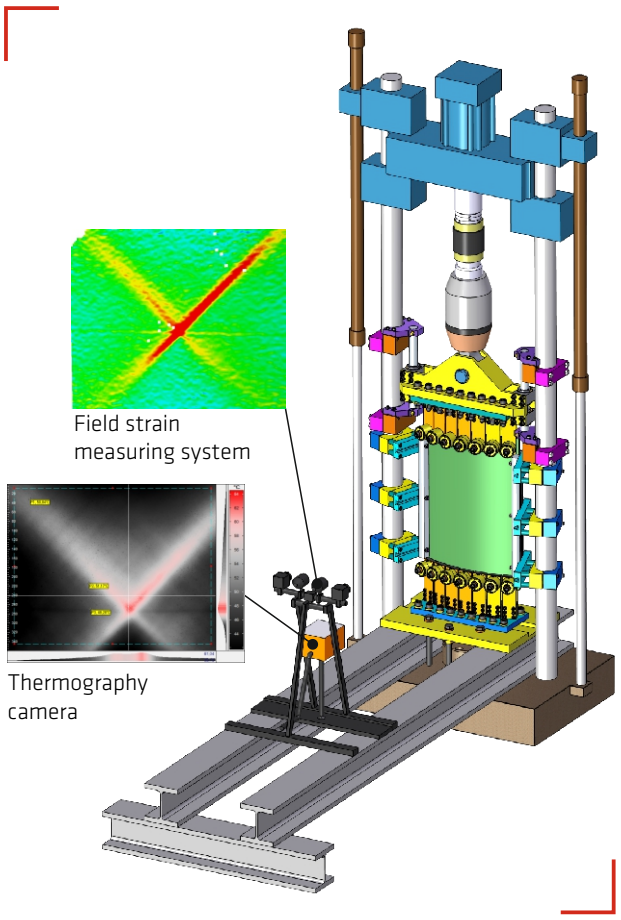
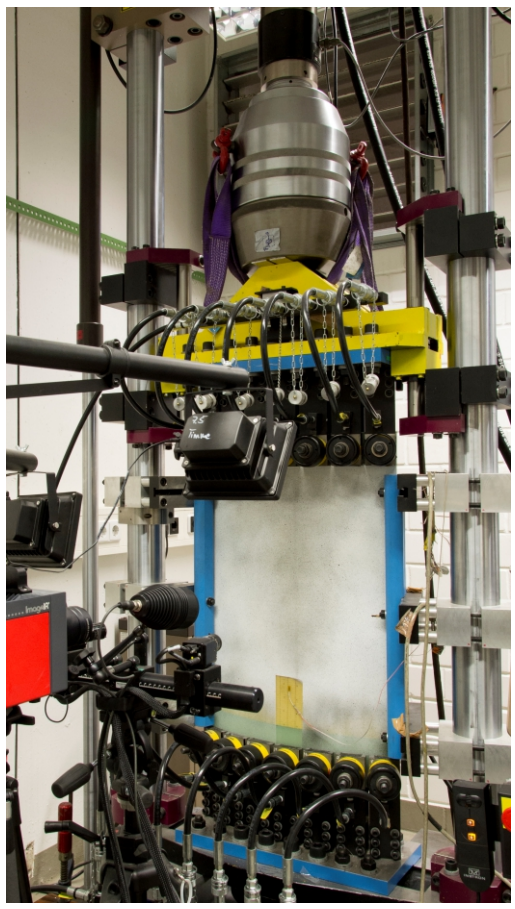
Motivation

Wind turbine rotor blades often fail significantly before their projected 20-year lifespan. This is because of imperfections (i.e. cracks) caused by operational fatigue which are present in the shell of the blades.
70-80% of these defects originate during the manufacturing process. Environmental conditions, especially for offshore turbines, then further damage the blades, leading to crack propagation throughout the body.
The cost-intensive outcomes are one of the inhibitors of wind turbine production. In addition, the sometimes very expensive „on the ropes“ repairs of the difficult to reach rotor blades lead to the replacement of entire blades rather than selective localized repair.



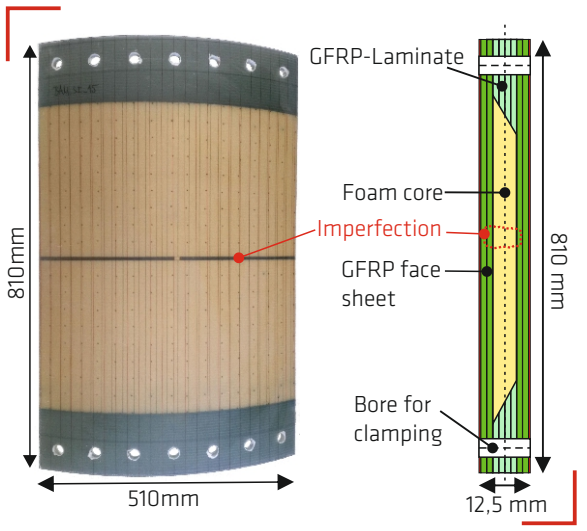
The shell test bench with integrated NDT
(field strain and thermography camera system)



The shell test bench, integrated into the 500 kN test machine

Shell Test Bench

The shell test bench developed by the BAM 5.3 allows for static and oscillatory testing of curved fiber-reinforced plastic (FRP) structures (i.e. glass fiber-reinforced plastics).
The shell test bench was integrated into a 500 kN axial test machine to simulate typical operational loads. The power of the test machine is distributed between 14 hydraulic cylinders. This unique, intentional construction of the test bench allows for a guaranteed homogeneous force applied to the test specimens.
A combined field strain and thermography camera system is used to non-destructively detect defects as well as their evolution. With this system, the development of defects can be followed in-situ during fatigue testing.



Shell test specimen (sandwich structure)

Test Specimens

The shell test specimens represent segments of the shell of intermediate scale wind turbine rotor blades. Production imperfections (i.e. gaps between foam pieces) are defined and reproducibly introduced into the test specimens.
The test specimen is designed and built as a sandwich structure, thus corresponding in its construction to a section of the outer shell of a real rotor blade, with respect to material and curvature. The materials (glass fiber textile core, support materials, and resin system) as well as the manufacturing method of the shell test specimens are modelled after rotor blade construction in industry. The test specimens can be produced in the BAM 5.3 or by an industry research partner.

Results

The tested imperfections show a fairly significant reduction (up to 90%) of the shell test specimens‘ lifetime.

Imperfection	Lifetime achieved
Single ply overlap	10 %, very critical
Resin channel > 3mm	50 %, critical
Double ply overlap	100 %, not critical

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