Technical University of Denmark

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Publication date:
2013

Citation (APA):
Mikkelsen, L. P. (2013). Testing composites for wind turbine blades. Abstract from International Conference on Future Technologies for Wind Energy, Laramie, Wyoming, United States.

International Conference on Future Technologies for Wind Energy
October 07-09, 2013, Laramie, Wyoming, USA

TESTING COMPOSITES FOR WIND TURBINE BLADES

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SUMMARY

In the last 30-35 years the chase for increased cost efficiency and thereby lowering the cost of energy for wind turbines has results in ever increasing turbine sizes where the individual blade having a length on 7-8m in the early 80's used for 50kW wind turbines to the recently produced prototypes with 73-83m long blades made for 5-10MW wind turbines. In parallel with the length, the weight for each blade has increased from 70kg to more than 30Mg. The large wind turbine blades can be considered as a long slender structure, where nearly all the load carrying capacity is taken by thick unidirectional (UD) laminates based on E-glass fiber reinforced thermosets such as polyester or epoxy. Even though E-glass is used as the reinforcement in nearly all commercial available large wind turbine blades, low price carbon fibers or other low density/high stiffness fibers has drawn increasingly interest for future blade generations. Important material properties are high material stiffness in order to maintain optimal aerodynamic performance and avoiding structural buckling, low density materials reducing the gravity forces and long-fatigue life and damage tolerance materials reducing the material degradation. The wind turbine blades is loaded both by a flap-wise bending moment coming from the aerodynamic forces and an edge-wise bending moment coming from the gravity forces. Loading which results in UD-composites loaded under either varying tensile, varying compressive or varying tensile-compressive loading. It should be noted that the failure mechanism of composites loaded in tension and compression is very different where the tensile strength is mainly given by the strength of the fibers while the compressive strength is govern by the growth of small fiber misalignment in combination with the shear loading of the matrix material.

Testing high strength unidirectional composites is a big challenge both in tension and compression. A challenge even more pronounced during fatigue loading. This is due to the large difference in the tensile-compressive strength which are of the order of 1GPa compared with the shear and transverse tensile strength which are of the order of 40-60MPa. In the presented study, these challenges have been addressed comparing results from finite element simulations with experimental measurements using thermo vision, digital image correlation and acoustic emission. Experimental techniques exploring detailed information on local material deformation and failure mechanism during material testing. The experimental techniques are used both for statically loading as well as for material loading in fatigue. In addition showing results from this study, prediction of the compressive strength of unidirectional composites is presented using an advanced non-linear composite material law as well as experimental results indicating the source for fatigue damage evolution during fatigue tensile loading.

Key Words: *Composite material, material testing, tensile and compressive strength, fatigue properties.*