English Abstract

Experimental and numerical study of the potential of wind turbine blade subcomponents testing.

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In October 2009, the European Commission published its Communication "Investing in the Development of Low Carbon Technologies", stating that wind power would be capable of contributing up to 20% of EU electricity by 2020 and as much as 33% by 2030. Significant additional research efforts in wind energy are needed to bridge the gap between the 5% of the European electricity demand, which is currently covered by wind energy, and one-fifth of electricity demand in 2020 and one-third in 2030.

A significant part of the required future installed wind power will be located offshore. New technologies beyond the existing knowledge base are needed. As the production of electrical power is linked with the rotor diameter of the Wind Turbine (WT), going offshore implies up-scaling the Wind Turbine Blade (WTB) dimensions and thus up-scaling the WT dimensions in total. The WTB is one of the basic components of the WT. A WTB of a 10MW WT has a length of 90 meters and weights 100 tons, while a WTB of a 20MW will have 126 meters length and will weight approximately 250 tons. Therefore, the design and manufacturing process of a very large WTB is a challenging task and new cost-efficient design methods become more important. One of the proposed methods is the building block approach, a state-of-the-art applied method in aerospace industry. It involves iterative analysis and testing procedures, conducted at increasing levels of structural complexity.

This dissertation focuses on the two first levels of the building block approach (coupon and subcomponent level) and is presented in two parts. Experimental work and analytical and numerical tools are combined to get a better insight of the mechanical behavior of WTB's structural materials and subcomponents and to gather and distribute the necessary information between the two levels.

In the first part (coupon level), thick adhesives and glass epoxy materials system are tested under quasi-static loads. Digital Image Correlation Technique (DICT) is employed to monitor the surface deformations, while Acoustic Emission (AE) Technique is used to detect and distinguish the failure mechanisms based on advanced signal processing methods. Experimental results are compared with finite element simulations using a progressive damage scenario in the effort to obtain useful information about the damage initiation and propagation.

In the second part (subcomponent level), a method recommending how to design, simulate and test subcomponents is developed. The method is illustrated by using I-beam structures, which simulate the complex stress state developed in the adhesive bond line between the spar caps and the shear web. The I-beams are subjected to four point bending and cantilever tests. An updated version of the first part's numerical method simulates the four point bending tests and is used as a tool to recommend alternative experimental set-ups. DICT, AE and Shearography monitor the mechanical behavior of the I-beams during the cantilever tests. Comparison between the experimental results of the coupons and the subcomponents leads to interesting information about the structural performance of the latter.