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Mikkelsen, Lars Pilgaard

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Visualizing composite materials for wind turbine blades using X-ray tomography

Lars P. Mikkelsen, DTU Wind Energy, Technical University of Denmark

Wind turbine blades is one of the human-made components experience most load cycles during its lifetime. High stiffness to weight properties as well as requirements of load-carrying materials with fatigue resistance against 50-300 million load-cycles during its 25 years operation is required. Due to its excellent fatigue performance, fiber-reinforced composite has been used in the last 40 years as the load-carrying material of wind turbine blades. During those years, the blades have grown in size. Forty years ago, typical wind turbine blades had a length of 7-10 meter. Now the longest blade have exceeded 100 meter in length. One of the result from this growth is that wind energy now is a cost-competitive energy source even compared with conventional fossil-based energy. Nevertheless, designing composite materials for modern wind turbine blades of such extensive length, a detailed understanding of the damage mechanism during cyclic fatigue loading is required. Here, x-ray computer tomography can play a central role. It is a experimental technique, making it possible, non-destructive, to follow the development of fatigue damage inside the material from its initiation to close to the final failure. In addition, a consistent link between the stiffness properties of the composite constituents and resulting composite laminate can be established. In the presentation, those stiffness links, as well as the fatigue damage evolution in typical blade material, will be revealed. It will be demonstrated how both the type of fatigue loading and the architecture of the fiber reinforcement plays a central role in the fatigue damage evolution inside the composite laminate. Knowledge making it possible designing composite materials for the even longer wind turbine blades of the future.