Durability prognosis of polymeric composite wind turbine blades

Miranda Rudolph, Siavash Peiday Saheli, James Earl, Serena Ferraro, Sonia Travaglini, Valeria La Saponara
Mechanical and Aerospace Engineering

Yingjun Zhao, Kenneth J. Loh
Civil and Environmental Engineering

University of California, Davis, CA

Abstract

Wind energy is currently one of the most cost effective, cleanest, and fastest growing renewable energy technologies. Wind turbines rely on the use of fiber-reinforced polymeric (FRP) composite blades because of their high specific strength and stiffness. A recent study shows the durability of these blades being affected by cracks, debonding, and impact damage, which are damage modes commonly encountered in FRP composites. The rotor assembly (blades and hub) was listed as having the second highest failure rate among all subassemblies analyzed. Enhanced understanding of the durability of these structures and effective damage monitoring would improve wind turbine safey and reduce downtime, thus lowering the resulting cost of energy and positively impacting the distribution of this clean energy across US.

In this NSF-funded project, we will first characterize the mechanical performance of laboratory-scale fiberglass/epoxy specimens, electro-sprayed by a piezoresistive carbon nanotube-polyelectrolyte film, to be fine-tuned as a sensor for this material. A small-scale (1.5 m) wind turbine blade, instrumented with this piezoresistive polymeric film, will be modeled with a simplified multiphysics finite element approach, and constructed with an in-house 5-axis CNC mill, vacuum assisted resin transfer molding and hand lay-up. The blade will be mounted on an existing 1 kW small turbine for field-testing.

Results from this project, particularly the field tests, will provide an important stepping stone towards a better understanding of the blade durability, and the adoption of this sensing system onto existing and new wind turbines and other large-scale wind excited structures.