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Analysis of SNL/MSU/DOE Fatigue Database Trends for Wind Turbine Blade Materials

John F. Mandell, Daniel D. Samborsky, Pancasatya Agastra, Aaron T. Sears and Timothy J. Wilson
Department of Chemical and Biological Engineering
Montana State University, Bozeman, MT 59717

Thomas Ashwill and Daniel Laird, Sandia Technical Managers

Abstract

This report presents an analysis of trends in fatigue results from the Montana State University program on the fatigue of composite materials for wind turbine blades for the period 2005-2009. Test data can be found in the SNL/MSU/DOE Fatigue of Composite Materials Database which is updated annually. This is the fifth report in this series, which summarizes progress of the overall program since its inception in 1989. The primary thrust of this program has been research and testing of a broad range of structural laminate materials of interest to blade structures. The report is focused on current types of infused and prepreg blade materials, either processed in-house or by industry partners. Trends in static and fatigue performance are analyzed for a range of materials, geometries and loading conditions. Materials include: sixteen resins of three general types, five epoxy based paste adhesives, fifteen reinforcing fabrics including three fiber types, three prepregs, many laminate lay-ups and process variations. Significant differences in static and fatigue performance and delamination resistance are quantified for particular materials and process conditions.

When blades do fail, the likely cause is fatigue in the structural detail areas or at major flaws. The program is focused strongly on these issues in addition to standard laminates. Structural detail tests allow evaluation of various blade materials options in the context of more realistic representations of blade structure than do the standard test methods. Types of structural details addressed in this report include ply drops used in thickness tapering, and adhesive joints, each tested over a range of fatigue loading conditions. Ply drop studies were in two areas: (1) a combined experimental and finite element study of basic ply drop delamination parameters for glass and carbon prepreg laminates, and (2) the development of a complex structured resin-infused coupon including ply drops, for comparison studies of various resins, fabrics and pry drop thicknesses. Adhesive joint tests using typical blade adhesives included both generic testing of materials parameters using a notched-lap-shear test geometry developed in this study, and also a series of simulated blade web joint geometries fabricated by an industry partner.