ABSTRACT

FATIGUE PERFORMANCE OF GLASS/EPOXY NANOCOMPOSITES FOR WIND

TURBINE BLADES

by

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Wind power is capable of becoming a major contributor to America's electricity

supply over the next three decades (Composite world, 2008). This desire is borne to

create a sustainable energy that will be cheap and easily adapted by people irrespective of

their geographical locations. Recently, there is a growing interest in designing cheap and

efficient turbine blades. Polymer matrix composites (E-glass/Epoxy) dominate the wind

turbine blade market because of their low-cost, superior fatigue characteristics, high

specific stiffness, and ability to make complex geometries. Different sizes of wind turbine

blades can be produced depending on the desired amount of power to be generated. The

length of wind turbine blade is proportional to the energy generated by the turbine and

this is the simple reason why longer blades are commonly designed by most wind turbine

blade designers. Wind turbine failure is a major issue as failure rates are as high as 20%

within three years (Richardson, 2009). Major causes of wind turbine failures are bad

bonds, delamination, voids and also manufacturing errors. Nanoparticles have been

discovered to enhance mechanical properties of existing materials (Blackman et al.,

2007). The overall objective of this research is to develop and manufacture glass/epoxy nanocomposites in conjunction with low cost vacuum assisted resin transfer molding (VARTM) for improved fatigue performance. EPIKOTE RIMR 135 epoxy resin was used which has been specially formulated for wind turbine applications by Hexion specialty Inc. Non-crimp E-glass ±45º stitched bonded fabric from Saertex, Germany was used as reinforcement because of its overall balanced properties and low cost.

Nanosilica and Halloysite nanotubes (HNT) were used to modify the epoxy resin system. Nanosilica did not pose any problem in dispersion because it was already dispersed in epoxy by the manufacturer, nanoresin AG. Germany. Three different loadings of Nanosilica (6, 7, and 8 weight percentages) were used in making composites and static tests were performed. Considerable improvements were recorded in tensile strength, tensile modulus, flexural strength, flexural modulus and interlaminar shear strength. Statistically, improvements in mechanical properties due to nanoparticle loading was found to be significant when compared to control (0 wt%) group.

However, 6 weight percent (wt%) nanosilica nanocomposites showed much improvement in tensile strength and interlaminar shear strength (ILSS) over control composites (0 weight percent nanosilica). Control and 6 weight percent nanosilica were tested in axial tension-tension fatigue at 2Hz frequency and R ratio of 0.1. 6 weight percent. Nanosilica modification showed 10 and 3 times improvement in fatigue life in high-cycle and low-cycle fatigue, respectively.

Halloysite nanotubes (HNT) was another nanoparticle that was used in this research. The uniform dispersion of HNT in epoxy was a challenge. Three different dispersion methods were explored; centrifugal mixing, high shear mixing and low shear

mixing. Dispersion with low-shear mixing was promising but it involved a very long and tedious process. More studies with different HNT percentages are required to confirm these improvements. There is also need to conduct detail SEM analysis especially on fractured surfaces to evaluate interfacial adhesion between epoxy and HNT particles.