Researchers build a tougher, lighter wind turbine blade

August 30 2011

Efforts to build larger wind turbines able to capture more energy from the air are stymied by the weight of blades. A Case Western Reserve University researcher has built a prototype blade that is substantially lighter and eight times tougher and more durable than currently used blade materials.

Marcio Loos, a post-doctoral researcher in the Department of Macromolecular Science and Engineering, works with colleagues at Case Western Reserve, and investigators from Bayer MaterialScience in Pittsburgh, and Molded Fiber Glass Co. in Ashtabula, Ohio, comparing the properties of new materials with the current standards used in blade manufacturing.

On his own, Loos went to the lab on weekends and built the world's first polyurethane blade reinforced with carbon nanotubes. He wanted to be sure the composite that was scoring best on preliminary tests could be molded into the right shape and maintain properties.

Using a small commercial blade as a template, he manufactured a 29-inch blade that is substantially lighter, more rigid and tougher.

"The idea behind all this is the need to develop stronger and lighter materials which will enable manufacturing of blades for larger rotors," Loos said.

That's an industry goal.

In order to achieve the expansion expected in the market for wind energy, turbines need a bigger share of the wind. But, simply building larger blades isn't a smart answer.

The heavier the blades, the more wind is needed to turn the rotor. That means less energy is captured. And the more the blades flex in the wind, the more they lose the optimal shape for catching moving air, so, even less energy is captured.

Lighter, stiffer blades enable maximum energy and production.

"Results of mechanical testing for the carbon nanotube reinforced polyurethane show that this material outperforms the currently used resins for wind blades applications," said Ica Manas-Zloczower, professor of macromolecular science and engineering and associate dean in the Case School of Engineering.

Loos is working in the Manas-Zloczower lab where she and Chemical Engineering Professor Donald L. Feke, a vice provost at the university, serve as advisors on the project.

In a comparison of reinforcing materials, the researchers found carbon nanotubes are lighter per unit of volume than carbon fiber and aluminum and had more than 5 times the tensile strength of carbon fiber and more than 60 times that of aluminum.

Fatigue testing showed the reinforced polyurethane composite lasts about eight times longer than epoxy reinforced with fiberglass. The new material was also about eight times tougher in delamination fracture tests.

The performance in each test was even better when compared to vinyl ester reinforced with fiberglass, another material used to make blades.

The new composite also has shown fracture growth rates at a fraction of the rates found for traditional epoxy and vinyl ester composites.

Loos and the rest of the team are continuing to test for the optimal conditions for the stable dispersion of nanotubes, the best distribution within the polyurethane and methods to make that happen.

The functional prototype blades built by Loos, which were used to turn a 400-watt turbine, will be stored in our laboratory, Manas-Zloczower said. "They will be used to emphasize the significant potential of carbon nanotube reinforced polyurethane systems for use in the next generation of wind turbine blades."

Provided by Case Western Reserve University