Vibration Testing and Structural Damage Identification of Wind Turbine Blades

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Wind energy in the United States is the fastest growing source of clean, renewable and domestic energy. A recent DOE technical report proposed the potential for meeting 20% of the nation's energy needs through wind power by 2030. This significant investment in wind turbines is motivating manufacturers to produce more efficient, yet complex, wind turbines. The trend in wind energy is also toward larger, longer (>50 m), and heavier (>7 tons) blades in order to generate more power.

Ensuring the reliability of wind turbine design is one of the most important aspects in enhancing safe and proper operation. It has been reported that monitoring the structural health of the turbine blades requires special attention as they are key elements of a wind power generation, and account for 15-20% of the total turbine cost. Recent studies also indicate that blade damage is the most expensive type of damage to repair and can cause serious secondary damage to the wind turbine system due to rotating imbalance.

In this project, the students will first characterize the dynamic parameters of 9-m CX-100 wind Blade, shown in Figures 1 & 2. Initial modal testing will be performed for both the 1-m section and the full-scale blades, and the results (resonant frequencies, mode shapes) will be compared and validated through the numerical model developed by Los Alamos researchers. This dynamic characterization and the model will be used to understand and predict the effects of blade damage on the system level performance of the wind turbines.

As time permits, students will also explore several structural health monitoring (SHM) techniques based on the novel use of piezoelectric active materials. The methods will include Lamb wave propagation, frequency response functions, and impedance-based methods. These three methods will be used to interrogate the 9-m wind turbine blades in this project. Some important design parameters in SHM, such as the traveling distance of the wave generated by the actuators, the sensing region of the sensor, the power requirement, will be characterized for successful implementation of such SHM systems.

Fig. 1: 9-m CX100 blade (courtesy of Sandia National Lab)

Fig. 1: X-section of the experimental CX-100 blade.

SCHEDULE

Weeks	Tasks
1	Orientation
2	Background research on the topics of piezoelectrics and papers listed below. Hardware use orientation.
3	Vibration testing/modal analysis of the 1-m section of the turbine blade with accelerometers and impact hammers
4-5	Vibration testing/modal analysis of the 9-m turbine blade with accelerometers and impact hammers
6-7	Experimental SHM investigation using piezoelectric transducers. Data analysis Begin write-up
8	Continue write-up, reiterate tests, codes, etc as needed.
9	Writing up of results and presentation

HELPFUL REFERENCES

1. U.S Department of Energy. “20% Wind Energy by 2030.” July 2008
2. Ciang, C.C., Lee, J.R., Bang, H.J., “Structural Health Monitoring for a Wind Turbine System: A review of Damage Detection Method,” Meas. Sci. Technol. 19 (2008), 122001.
3. “Innovative Design Approaches for Large Wind Turbine Blades,” TPI Composites, Inc., Project Report for SNL, SAND2003-0723, March 2003.
4. Ashwill, T.D., “Some Recent Trends & Activities in Turbines and Blades,” Sandia National Laboratories 2nd Wind Turbine Blade Workshop, April 2006.
5. TPI Composites, *Innovative Design Approaches for Large Wind Turbine Blades; Final Report*, SAND2004-0074, Sandia National Laboratories, Albuquerque, NM
6. White, J.R., Adams, D.E., Rumsey, M.A., “Modal Analysis of CX-100 Rotor Blade and Micon 65/13 Wind Turbine, Proceedings of the IMAC-XXVIII, Feb. 1-4, 2010, Jacksonville, FL
7. Light-Marquez, A., Sobin, A., Park, G., Farinholt, K., “Structural Damage Identification in Wind Turbine Blades using Piezoelectric Active-sensing,” Proceedings of the IMAC-XXVIII, Feb. 1-4, 2010, Jacksonville, FL
8. Park, G., Sohn, H., Farrar, C.R., Inman, D.J. 2003. “Overview of Piezoelectric Impedance-based Health Monitoring and Path Forward,” *The Shock and Vibration Digest*, **35**(6), 451-463.