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Characterization of a 9 Meter Sensor Equipped Turbine

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INTRODUCTION

The Sandia National Laboratories, Wind Energy Group in collaboration ~~cooperation~~ with the West Texas A & M University, Alternative Energy Institute, and the United States Dept. of Agriculture, Agricultural Research Service conducted a test on a set of sensor equipped 9 meter blades. These blades were characterized by using a laser positioning device.

Smart turbines are envisioned that combine innovative sensor measurements, new data analysis and control algorithms, and rotor-based aerodynamic actuators to (1) reduce operations and maintenance costs through structural health and prognostics management and (2) reduce cost of energy by improving performance with adaptive turbine control and collective wind farm control. To enable this technology Sandia Laboratories Wind and Water Power Technologies is leading a Sensored Rotor effort to determine the optimal number, type, and location of sensors through simulation and followed by test validation. Additionally, sensor installability ~~install ability~~, survivability, and reliability are being investigated. With respect installability ~~install ability~~, a laser positioning device was envisioned to have sufficient accuracy to determine sensor placement and orientation which are critical for the advanced data processing algorithms. A set of 3 CX-100 rotor blades were instrumented at the USDA-ARS Conservation and Production Research Laboratory with DC triaxial and uniaxial accelerometers, fiber optic temperature and strain measurements, strain gages, surface pressure taps, hot-film stagnation point, and five-hole pitot tube. To locate the position and orientation of the sensors the blades were mounted on a static pull fixture with the blade supported to reduce the effect of gravitational load and tip motion. A laser positioning device was then used to orient a coordinate system to the rotor blade and then measure points, planes and cylinders that ~~which~~ defined the location and orientation of the sensors. The results from this test will be used in the data analysis algorithms applied to the operational measurements of the rotor. ~~data while the system is in operation.~~

Laser Positioning Device

The laser positioning system tracks the laser target device as it is manually moved along the blade surface and logs this movement in an X, Y, Z Cartesian coordinate system format that can be converted to a Computer Assisted Drawing file.

Laser Target Device

The SMR is a precision diameter steel ball with one side machined out to house three mirrors that are positioned to create a corner, much like the corner of a room. When the laser beam hits the SMR, it is reflected back into the tracker where it hits 4 photo sensors called a quadcell. This quadcell sensor controls the motors and tells them which way to drive to keep the beam centered on the sensor

Preparing Blade For Test

Blade Support Placement

Calibration of Positioning System

This research was conducted to ~~confirm~~ measure the ~~proper~~ placement and orientation of sensors ~~and~~ in order to allow for the proper correlation of the data that will be recorded when the blades are placed in operation. The data obtained from this test will be analyzed to find the structural stress, and integrity of the blades and the load characteristics of the rotor in different wind profiles and turbulence. This data will allow advances in active rotor research as well as health monitoring of multiple components: blade integrity, bearing load, rotor loads, ~~G~~ centrifugal force loading and temperature differentiation of various surfaces. This will also be a proof of concept that will lead to a set of blades built with embedded sensors and aerodynamic reactive control surfaces. ~~that will have all of the sensors placed on the inside and reactive surfaces built in. Determinations of this~~Results from this data could lead to better performance and health monitoring concepts applicable to existing and future wind turbine installations.