GREEN TECHNOLOGY ACCELERATOR CENTER

CASE STUDY

NYSP2I's Evaluation of Active Flow Control (AFC) Modules for Wind Turbine Applications

XC Associates, Inc. (XCA) located in Stephentown, New York, is a manufacturer of advanced composite structures, supporting various consumer and industrial applications, including the aerospace and wind turbine industry. XCA is expanding their product portfolio and developing new products to enhance the performance and durability of composite wind turbine blades. XCA's Active Flow Control (AFC) modules, which include synthetic jets (SJ) and deployable vortex generators (DVG), are intended to actively reduce air flow separation and the recirculation region across wind turbine blade surfaces, reducing turbine blade vibration and increasing the life span, reliability and performance efficiency of the turbine.

CHALLENGE

XCA requested New York State Pollution Prevention Institute (NYSP2I) and its partner university Rensselaer Polytechnic Institute (RPI) to research the impact of wind turbine blade vibration on system durability, and perform a high-fidelity numerical analysis on the placement of AFC modules applied to the wind turbine blade to optimize turbine performance and life cycle. XCA identified a specific wind turbine application for analysis, based on their target market, and requested NYSP2I and RPI to evaluate the placement of their new AFC modules relative to flow separation and turbine performance.

SOLUTION

The project proceeded with NYSP2I personnel evaluating the durability of existing wind turbine systems, with the opportunity to reduce system failures and operational costs. In parallel, under the guidance of Dr. Onkar Sahni at RPI, a Computational Fluid Dynamic (CFD) model to study the impact of the AFC device placement on flow separation over the turbine blade. The optimization of flow across the blade surface will improve the energy efficiency and reduce vibration affecting key subsystems of the turbine.

RESULTS

NYSP2I researched and identified the top 6 sub-system failures in wind turbines, impacting total cost of ownership by >20% over the product life cycle of 25 years. The following wind turbine subsystems were identified as primary contributors to failure frequency, cost and downtime:

- Electrical System, Gearbox, Bearings, Generator, Pitch, and Yaw control

NYSP2I further studied cases of the critical failures, diagnosing unsteady loading on the mechanical system as being a key contributor to turbine system failures. RPI identified opportunities for reducing the load variation by application of AFC modules to the wind turbine blades, confirmed by CFD modeling.

CHALLENGE

- XCA requested NYSP2I and RPI to research the impact of wind turbine blade vibration on system durability, and perform a high-fidelity numerical analysis on the placement of Active Flow Control (AFC) modules applied to the wind turbine blade to optimize turbine performance and life cycle

SOLUTION

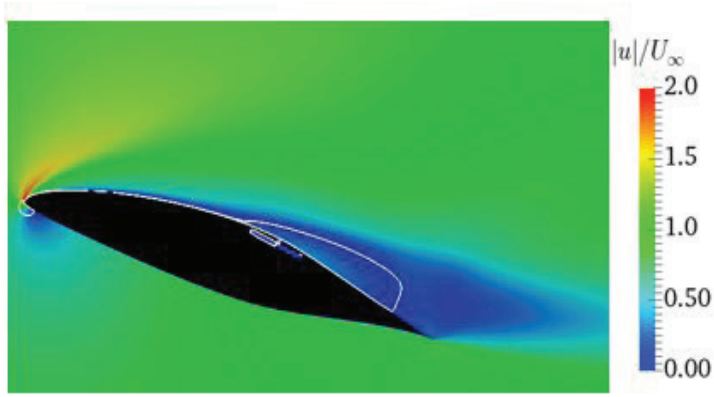
- NYSP2I evaluated the durability of existing wind turbine systems
- RPI developed a Computational Fluid Dynamic (CFD) model to study the impact of the AFC device placement on flow separation over the turbine blade

RESULTS

- NYSP2I researched and identified the top 6 sub-system failures in wind turbines, impacting total cost of ownership by >20% over the product life cycle of 25 years
- NYSP2I diagnosed unsteady loading on the mechanical system as being a key contributor to top failures
- RPI optimized placement of the AFC devices on the blade surface to actively reduce air flow separation and the recirculation region across wind turbine blade surfaces, improving turbine performance and efficiency
- Success of this product line is forecasted to help create fifteen (15) NYS jobs over three years

XCA ADVANCED COMPOSITES DESIGN & MANUFACTURING

RPI analyzed the baseline turbine operation for flow separation using the CFD model and identified opportunities for placement of AFC modules to optimize flow over the turbine blade surface.



Flowfield analysis of Active Flow Control - applied to a wind turbine blade

As a result of the CFD modeling, RPI optimized the placement of the AFC devices on the blade surface to actively reduce air flow separation and the recirculation region over wind turbine blade surfaces, improving turbine performance and efficiency.

Key findings of the flow optimization study include:

- AFC modules, comprised of Synthetic Jets (SJ) and Deployable Vortex Generators (DVG), led to a delay in flow separation and reduction in recirculation region over the wind turbine blades, thus improving turbine performance and reducing load variation vs. the baseline turbine blade without AFC
- At higher angles of attack, SJ and DVG actuators resulted in enhanced lift force and turbine performance
- The delay in flow separation and reduction in recirculation region attained with AFC inherently suppresses the unsteadiness in aerodynamic loading experienced by the airfoil, which in-turn will decrease turbine blade vibration and improve the durability of the turbine blade and downwind mechanical systems

The results of this project will assist XCA to further apply and commercialize their AFC modules, improving wind turbine performance and durability. Success of this product line is forecasted to help create fifteen (15) New York State (NYS) jobs over three years.

PROJECT RESOURCES

Rochester Institute of Technology
- Golisano Institute for Sustainability

Rensselaer Polytechnic Institute
- SCOREC - Scientific Computer Research Center
- Center for Flow Physics and Control
- Center for Future Energy Systems
- Center for Computational Innovations

TESTIMONIAL

"Working with NYSP2I was an incredible experience. The team at Rochester Institute of Technology (RIT) and Rensselaer Polytechnic Institute (RPI) provided valuable information to support marketing the active flow control modules (AFC). RPI provided essential Computational Fluid Dynamic (CFD) analysis that will be used to support our full scale testing at NREL later in 2017. Test data showing the ability of the Active Flow Control Modules (AFC) to reduce vibration in the wind turbine system is crucial in marketing this new technology to OEM blade manufacturers. The excellent CFD work that the team at RPI provided will allow XCA to ensure that the full scale testing that is performed will showcase the full potential of this technology."

– Lynda Fiorini, Vice President
XC Associates, Inc.

NYSP2I PARTNERS

R·I·T Rensselaer

University at Buffalo
The State University of New York

Clarkson UNIVERSITY

New York Manufacturing Extension Partnership

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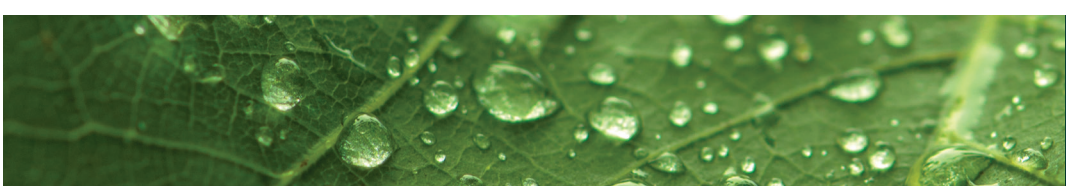

R·I·T Golisano Institute for Sustainability
ROCHESTER INSTITUTE OF TECHNOLOGY