Technology Innovation Announcement
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Advanced Blade Technology

UNIVERSITY OF NOTRE DAME

Office of Technology Transfer

Smart Turbine Blades Using Single Dielectric Barrier Aerodynamic Plasma Actuation

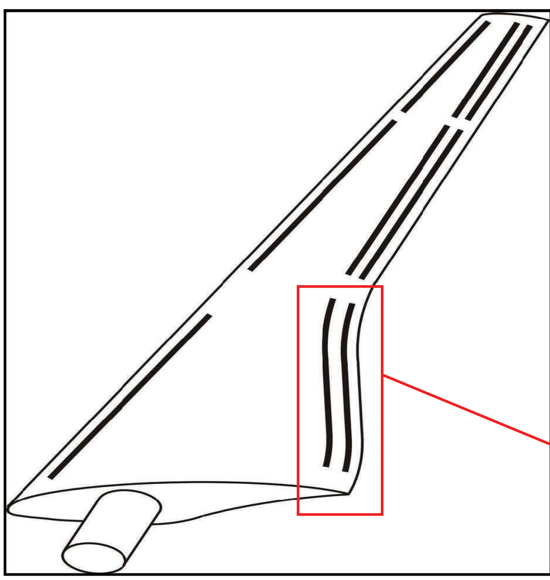
US Patent No. 7,380,7561 B1 and other Patents Pending

Background

The University of Notre Dame Center for Flow Physics and Control (FlowPAC) has pioneered the development of plasma actuators for aerodynamic control. Patented technology for the application of plasma-enhanced flow control of wind turbines will translate into increased capacity, normalized output, decreased structure weight, and decreased cost. A proof of concept of plasma-based aerodynamic control on wind turbine blades was demonstrated in 2008 and verified gust force alleviation for the full range of full-scale wind turbine speeds while increasing energy capture.

Technology

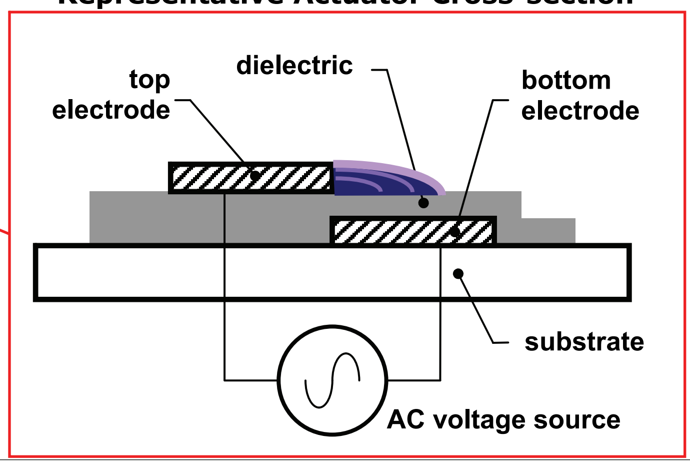
A single dielectric barrier aerodynamic plasma actuator apparatus based on the dielectric barrier discharge phenomenon for application to aerodynamic uses in drag reduction, stall elimination, and airfoil efficiency improvement and optimization. Non-uniform in time and space, partially ionized gasses are generated by one or more electrode pairs each having one electrically encapsulated electrode and one air stream exposed electrode with energization by a high-voltage alternating current waveform.



Advantages

- Increased Airfoil Efficiency & Energy Capture
- Lower Cut-in & Higher Cut-out speeds
- Reduced blade weight & turbine noise
- Gust force mitigation
- Normalized output

Representative Actuator Cross-section



UNIVERSITY of NOTRE DAME
Aerospace and Mechanical Engineering

Interested in Licensing or Sponsored Research opportunities?

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Contact: Office of Technology Transfer → **commercializing success**
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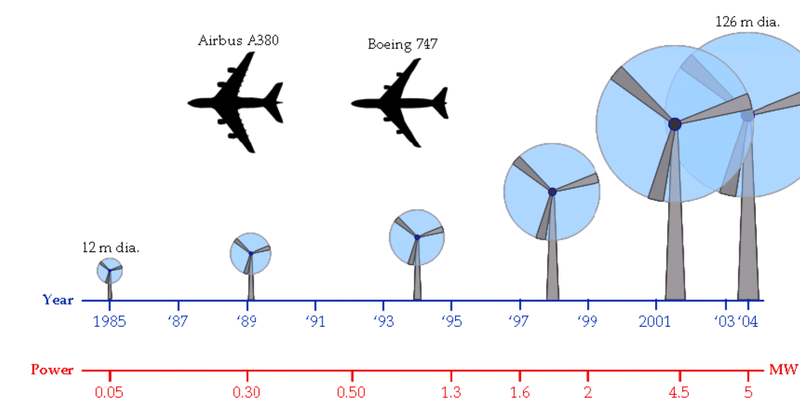
Wind Energy Research at the University of Notre Dame

Department of Aerospace & Mechanical Engineering ~ Center for Flow Physics & Control

Larger Blades = Greater Energy Capture



What is a Smart Wind Turbine?

The Center for Flow Physics and Control (***FLOW PAC***) at the University of Notre Dame have pioneered the development of the Plasma Aerodynamic Control Effectors (PACE) concept for improved performance of wind turbines. The concept is aimed toward the design of "smart" wind turbine blades with integrated sensor-actuator-controller modules to improve the performance of wind turbines. The system will be designed to enhance energy capture, and reduce aerodynamic loading and noise by way of virtual aerodynamic shaping. Virtual shaping is the modification of the flow field around the surface by means of flow control (plasma actuators), which results in flow changes as if the geometry itself is altered. In effect the flow control scheme is giving the designer the capability to change the aerodynamic distribution across the turbine blade as needed to control the blade loading.

Benefits of Active Flow Control on Wind Turbine Performance

Benefits of Active Flow Control Technology	*Wind Turbine Improvement*
Distributed ***Virtual Plasma Flaps*** can be used to control large transient loads due to unsteady wind conditions.	Controlling transient blade loading lowers blade root bending moment transients. *This will improve turbine blade fatigue life and allows operation over a wider range of wind conditions.*
Distributed ***Virtual Plasma Flaps*** can be used to control rotor speed.	Emergency shut down requires redundant control capability. ***Virtual slats and flaps*** could be used to help brake the turbine by provide braking torque. *This will provide greater control flexibility.*
Distribute ***Virtual Plasma Flaps*** can allow larger span turbine blades.	Turbine blades of greater span can be designed if load control is available to attenuate transient blade loading due to unsteady wind conditions. *Increasing blade span permits greater energy extraction.*
Wind turbine spacing is governed by wake flow interference between wind turbines in the wind farm. Distributed ***Virtual Plasma Flaps*** may allow more efficient turbine performance from down wind turbines.	***Virtual Plasma Flaps*** can allow improve energy extraction from down wind turbines by optimizing the aerodynamic loads across the blades. *May allow more wind turbine to be placed on a given track of land than is currently possible.*
Distributed ***Virtual Plasma Slats*** can control C_{Lmax} that will allow improved performance on stall regulated wind turbines. It may also be useful in turbine startup.	***Virtual Plasma Slats*** could be used to control blade section C_{Lmax} .

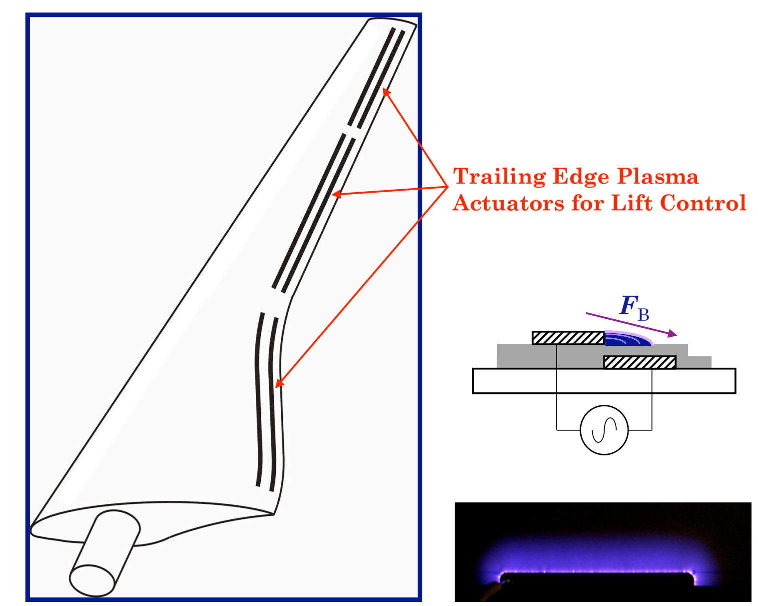
Wind Turbine Cost Drivers

The rotor is generally the highest cost component and must be the most reliable for safety. While increasing turbine blade size allows for greater energy capture it requires heavier blades. Increasing blade weight requires increased strength (weight) in the power-train and gear box, tower and foundation support structure. To lower the cost of future large wind turbines one must lower the weight of the blades.

Blade Weight Reduction Technologies:

Advanced structural airfoils
Adaptive structures, new materials
More efficient designs by considering structural and aerodynamic design simultaneously
Distributed active aerodynamic control

Distributed Active Flow Control to Reduce Unsteady Blade Loading



Virtual trailing edge flaps based on *plasma actuators*

UNIVERSITY OF NOTRE DAME

Research conducted at the Hessert Laboratory for Aerospace Research under the direction of

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FlowPAC ND