The potentials of the controllable rubber trailing edge flap (CRTEF)

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The potentials of the controllable rubber trailing edge flap (CRTEF)

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OUTLINE

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- The CRTEF
- Wind tunnel test results
- Potential load reductions
- Summary and outlook
Background

- non-uniform rotor loading from turbulence increases with size of rotor
- a distributed control along the blade has advantages for load alleviation and for stability control
- numerical studies (e.g. Buhl 2005 and Andersen 2009) show considerable load reduction potentials using flap control

Andersen, P.B., Henriksen, L., Gaunaa, M., Bak, C., Buhl, T. “Deformable trailing edge flaps for modern megawatt wind turbine controllers using strain gauge sensors”. WIND ENERGY Wind Energ. (2009) Published online. DOI: 10.1002/we.371
Background – flap technology

What flap technology can be used?

- piezo electric flaps (Bak et al. 2007)
- deployable tabs (van Dam et al. 2007)


The CRTEF

Development work started in 2006

Main objective: Develop a robust, simple controllable trailing edge flap

The CRTEF design:
A flap in an elastic material as e.g. rubber with a number of reinforced voids that can be pressurized giving a deflection of the flap
The CRTEF development

Comsol 2D analyses
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Wind tunnel experiment

airfoil section + flap during instrumentation

the 2m airfoil section with the flap in the VELUX wind tunnel, December 2009
Wind tunnel experiment

two different inflow sensors
VELUX WIND TUNNEL EXPERIMENT

NACA0015 airfoil section with
WITH RUBBER TRAILING EDGE FLAP
AOA = 8°

MEAS: \( \beta = 2.4° \)

MEAS: \( \beta = -8.0° \)
0.1 Hz, beta step

DAY 1
\[
\alpha = 0^\circ \quad \alpha = 2^\circ \quad \alpha = 4^\circ \quad \alpha = 6^\circ \quad \alpha = 8^\circ \\
\alpha = 10^\circ \quad \alpha = 12^\circ \\
\]

\[C_L - C_{L,0}(\beta = 0)\]

\[t^* = t/(c/V_0)\]
A MODEL FOR THE RUBBER FLAP RESPONSE

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Pitching with a traditional wind turbine blade section

Pitching with a CRTEF
Aero-elastic simulations
Single flap - 30% of the blade
Control input from simulated strain gauge
Homogenous turbulent inflow
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Summary and outlook

- The basic principle of functioning of the CRTEF has been proven.
- Aerodynamic and aeroelastic characteristics documented through wind tunnel tests.
- First aeroelastic simulations using wind tunnel flap characteristic as input indicate 50 percent load reduction potential.
- New development project formulated to bring the CRTEF technology up to a stage where it is ready for testing on a fullscale MW turbine (time frame about 2 years).