Testing of a new morphing trailing edge flap system on a novel outdoor rotating test rig

Aagaard Madsen, Helge; Barlas, Athanasios; Løgstrup Andersen, Tom

Publication date:
2015

Document Version
Peer reviewed version

Link back to DTU Orbit

Citation (APA):
Testing of a new morphing trailing edge flap system on a novel outdoor rotating test rig

Helge Aagaard Madsen
Thanasis Barlas
Tom Løgstrup Andersen

DTU Wind
Technical University of Denmark
(former Risoe National Laboratory)
P.O. 49, DK-4000 Roskilde, Denmark

hama@risoe.dtu.dk
Why use flap control?

Flaps are among the best devices for changing lift

Flap system technology

Strong requirements from the wind turbine industry to the technology

- robust and reliable (20 years lifetime)
- no metal parts
- no electronics
- no mechanical parts
- scalable to the large blade sizes (100m)

Piezoelectric actuators in wind tunnel exp. 2007 (DTU)
The Controllable Rubber Trailing Edge Flap CRTEF development

Development work started in 2006

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

The CRTEF design:

A TE flap in an elastic material with a number of voids that can be pressurized giving a deflection of the flap
The Controllable Rubber Trailing Edge Flap CRTEF
Some milestones in the CRTEF development

- In 2007 a 1m long prototype rubber trailing edge flap was tested – problems with its robustness
- In autumn 2008 promising results with a 30 cm prototype with chordwise voids
- December 2009 wind tunnel testing of 2m long flap section
- March 2011 - 2014 the project "Industrial adaptation of a prototype flap system for wind turbines –INDUFLAP" was conducted
Two basically different designs have been investigated during the INDUFLAP project.

Prototype with spanwise voids - suited for manufacturing by extrusion

Prototype with chordwise voids – mold manufacturing in 2D and 3D
The flap design chosen for testing on a 2m span blade section

The load carrying part

The two active parts, manufactured by extrusion, assembled with the load carrying part
The flap design chosen for testing on 2m span blade section
Overall concept for blade with flaps

- Main blade is designed and manufactured without the trailing edge part (10-15% of chord)
- A spar is inserted at the TE with an attachment component for the flap
- From the region where flat back airfoils ends, flaps are used along the whole span out to the tip
- A combination of passive flaps (3D mold manufactured) and 2D active flaps manufactured by an extrusion process are used
Testing

- testing prototypes in the laboratory – e.g. for flap angle and time response -- done (2008-2009)
- wind tunnel testing for measuring the aerodynamic performance -- done (2009)
- we developed a rotating test rig for testing the flap system in the rotating environment and with the real turbulent inflow – done (2013-2014)
- full scale testing on a MW turbine - - to come
Rotating test rig
Based on a 100 kW turbine platform

Intended to minimize the gap between wind tunnel testing and fullscale testing

- testing in rotating environment with realistic g-loading
- real turbulent inflow
- combine pitch and flap control
- detailed aerodynamic pressure measurements
Blade section 2.2x1m with detailed instrumentation with pressure taps
Boom installed in June 2014
Rotating test rig in operation September 2014
Results – downwind operation

Flap angle changed in steps at each 10 sec.
Results – compare flap and pitch action

Change in normal force from 15 deg. change in flap angle equals about 3 deg. change in pitch
Summary and outlook

- Successful industrial manufacturing of flap prototype by an extrusion process in a polymer material.
- Rotating tests of 2.2m flap section proved functioning up to 10g loading.
- Atmospheric testing on rotating test rig showed that 5deg. flap angle gave same change in loading as 1 deg. pitch.
- The next step involving an OEM aims at testing an active flap system on a MW turbine – project funded by the Danish EUDP programme ongoing.
Acknowledgement

The INDUFLAP project was funded by the EUDP programme from the Danish Ministry of Energy with about 1.6 mill $ and by eigen-funding from the industrial participants.
Thank you for your attention!