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Active aerodynamic control of wind turbine blades with high deflection flexible flaps

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The implementation of an innovative aerodynamic control technique in wind turbines is a point under extensive investigation since the conventional wind turbine blade technology is reaching its limits. Almost all the effort of the wind turbine industry in the field of aerodynamics is related to the development of blades which offer better performance, increased reliability and faster control of larger wind turbines. Currently, however, most of the research effort is focusing on the implementation of aerodynamic elements for dynamic load alleviation during wind turbine operation rather than rotor stall control or even more the complete wind turbine power regulation which is the ultimate target of the current project. The current document presents the test process, methodology and results of wind tunnel test campaigns on the investigation of the flexible flap configuration as a possible means of aerodynamic control of wind turbines. The test campaign took place at the HFI/TU Berlin wind tunnel. Measurements were performed with a model of the DU96W180 airfoil as well as with the modified-DU96W180 test airfoil section equipped with the flexible flap assembly in flow with Reynolds number Re equal to 1,300,000. The The flexible flap was tested in various positive and negative deflections in order to extract its complete operational curve. The results showed significant influence on both lift and drag as well as strong variations on the pitch behavior of the wing. The paper also discusses the possible benefits of the integration of flexible flap systems in wind turbine blade structures.

Nomenclature

Re	Reynolds Number
A	Cross-sectional area of the measurement section $[m^2]$
l	Length of the measurement section [m]
$U_{s_{max}}$	Free stream velocity $[m/s]$
AoA	Angle of attack $[^o]$
a	Test wing span [m]
c	Wing chord [m]
b_1	Distance between left outer wall and splitter wall [m]
b_2	Distance between right outer wall and splitter wall [m]
u_{b_1}	Flow speed at the Pitot tube $[m/s]$
u_{b_2}	Flow speed at the Pitot tube $[m/s]$
C_l	Lift Coefficient
C_d	Drag Coefficient
C_m	Moment Coefficient

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