CFD Analysis of Flow Separation on Thick Airfoils with Fluidic Devices

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1 Introduction

The flow separation in the root area of rotor blades is a generally problem of the blade aerodynamics. On very thick profiles and the cylindrical part of the blade the line of separation reaches up to about 50% of profiles chord. The separation could cause secondary flow in spanwise direction up to 30% span of the rotor blade. This potentially causes negative effects on the flow around the blade at higher spanwise areas which are not directly affected by such separation problems.
One chance to optimize the flow and minimize the separation is to control the flow by fluidic devices. This is an often used method in the airplane industry.
Nowadays fluidic devices in rotor blade aerodynamics are an often analyzed theme. One of the most interesting questions is the effect of different types with different geometrically characteristics and installation values.

2 Fluidic devices

All the fluidic devices are so called mixing devices which are generating vortices in the flow. The vortices should mix high energy flow into the boundary layer. This causes the boundary layer to follow the profiles surface for a longer distance.
This scientific work compares three types of fluidic devices. The first one is the often used Vortex-Generator. These are two little fins made of steel or plastic installed in a defined angle to the main flow on the suction side of the profile. Type two and three are tetrahedral elements installed in two reverse directions so called ramp and plow. All devices are shown in Fig. 1.

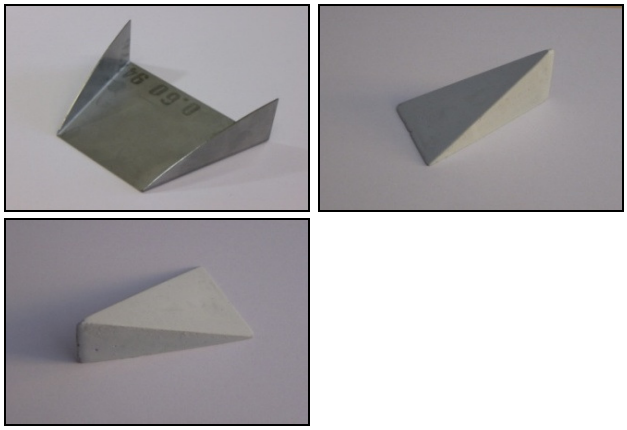

Fig. 1: fluidic devices: Vortex-Generator, ramp, plow

3 Numerical simulation

For the numerical simulations a represented profile of a 1,5 MW wind turbine rotor blade was selected. In order to compare the devices the aerodynamic characteristics especially the lifting coefficient and the drag coefficient for each type were calculated at several operating points of the wind turbine. All calculations were done with a Navier-Stokes solver and an unsteady, fully turbulent flow regime.

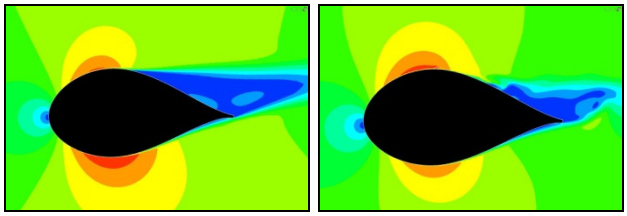

Fig. 2: contour plot of velocity/ blank profile on left hand side in compare to Vortex-Generator

The results of the study show clear tendencies for positive effects in minimizing flow separation with the fluidic devices. Dependent of the geometrically shape the effects of the different types are different. Nevertheless all analyzed types of fluidic devices are able to minimize the flow separation locally more or less. The best results are shown by the Vortex-Generator and the plow. That means the plow is an alternative fluidic device that gives new options in means of material and installation.